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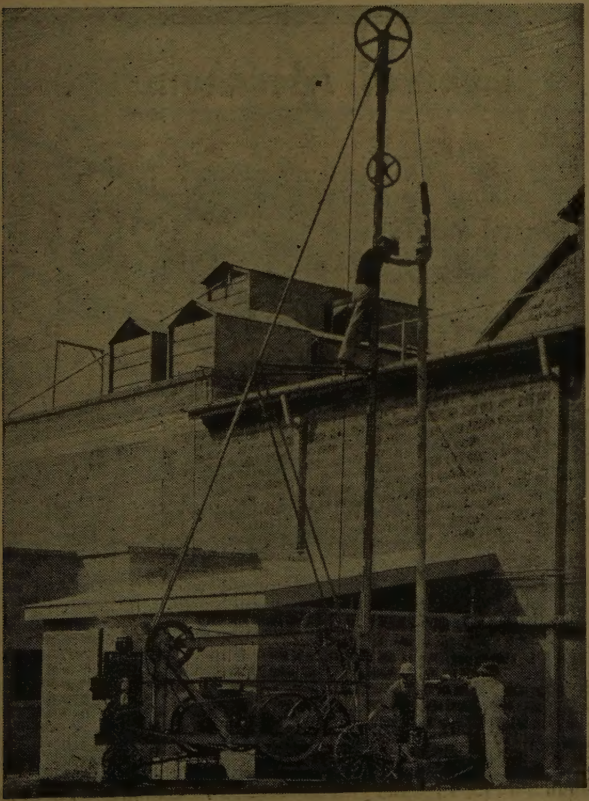

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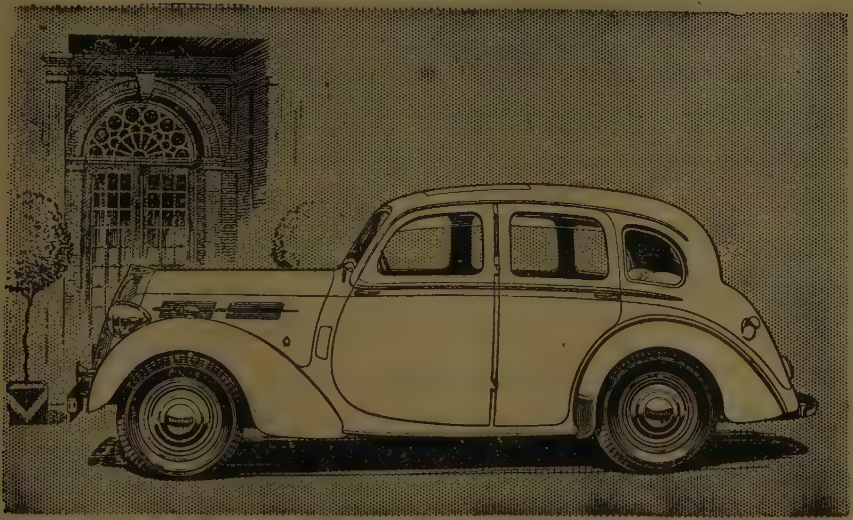

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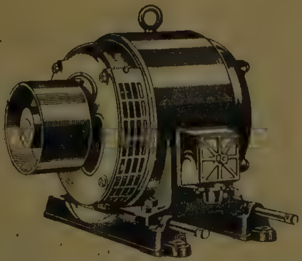

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THE YANGAMBI CONFERENCE

The agricultural conference which was recently held at Yangambi in the Belgian Congo was a complete revelation to the East African delegation. For the last twenty-five years technical officers in local departments of agriculture have struggled along, with the limited funds and staff available, and on the whole have accomplished very excellent work. But Yangambi, under the auspices of the Institut National pow l'Etude Agronomique du Congo-Belge (I.N.E.A.C.), is the scientific worker's dream of Utopia. Adequate qualified staff, good housing, no shortage of funds, the very best technical equipment procurable (and most of it British made at that) and an adequate monetary reward.

It has been stated, and only recently repeated by a distinguished scientific visitor, that British research men with their limited numbers have on more than one occasion produced the answer when other countries more copiously endowed have failed to do so. That indeed may be so—but it is necessary to face the fact that hitherto East Africa has always sent a boy to do not the work of one, but of several men.

At the central station at Yangambi there are eighty highly qualified scientists and forty more are working at subsidiary stations. As problems arise the necessary teams can be made available.

At Yangambi work can be planned for future development as the staff is relieved from the solution of day to day problems. Already the results from the breeding of oil palms has increased commercial palm oil production in no uncertain manner. In every direction the staff is adequate to guarantee results from proper planning with adequate facilities.

How different in East Africa. Apart from a couple of not entirely satisfactory cotton varieties, some good strains of wheat and an odd maize it would be difficult to point to any type of grain or other crop which has been evolved in East Africa and which is grown on a commercial scale to-day. Our paucity of trained workers has compelled them to devote so much of their energies to advising farmers and others that any research they may have found the opportunity for has been mainly extension work.

East Africa's problems—the rehabilitation of our soils (often in areas closed to cattle because of tsetse), the urgent need for drought resistant varieties of African grain crops, the establishments of others resistant to disease and pests—cannot wait on the results of these parsimonious piecemeal efforts.

A vote of five to ten million pounds is regarded complacently when improvements of roads are under consideration but hitherto in East Africa it has been difficult to "put it over" that without adequate provision for research, the answer will be delayed.

R. W. R. M.

FIRE AND FOREST

In Tanganyika, from the point of view of destruction of vegetation by fire, evidence points to 1946 being a typical year, if such there is, in that fires were particularly bad in the early months but not nearly so bad in the latter part of the year. The two regions most vulnerable to fire damage in the year reviewed both started badly and ended well.

As the writer was leaving a well-known town in January, 1946, the landscape reminded him of a rather too realistic picture of the end of the world inspired by Calvinist doctrine. Flames belched forth from one side of a mountain, semi-darkness covered the earth, relieved only by the reflections of tongues of flame on a dark pall of smoke and black smuts were falling everywhere. There is no reason to doubt a report that this holocaust, by carelessness or indifference, was caused, in part at least, on a European farm.

In the other district the local forest officer in provincial conference stood out for a compulsory communal turn-out and for communal punishment in the event of failure to turn out to fight forest fires. His ideas were not accepted and instructions were issued to Chiefs that they and their people were responsible for the protection from fire of portions specified of the boundaries of forest reserves near their villages. In the area where the worst fire of the year occurred, a village was certainly near the forest reserve concerned although its headman lived on the main road some miles away. He issued orders, but not being present himself, those orders were either ignored or not obeyed to an adequate extent and 25 square miles of forest land were over-run by a fierce fire. This area was by no means destroyed but it was badly damaged and tree regeneration was retarded.

These are but two examples from many which go to prove how difficult is one hundred per cent fire protection. Alternatives must therefore be sought but what are they? There is the Grass Fires (Control) Ordinance which is optional and can be adopted by districts or by provinces and can be applied by notice of Gazette. It has been adopted by only two provinces and by certain smaller settlements in the Territory but even where applied has not been entirely successful. The African has a hundred and one valid reasons for starting fires, be it to improve his pastures or to exterminate the rats or other rodents which took toll of his crops or to drive away wild animals, real or imaginary, and having started a fire he has little conscience about what happens later. So two communities seem to have members who, Gallio-like, do not care: the former is probably the exception while the latter almost certainly is the rule.

The remedy? Legislative enactments of Central Government certainly, if they can be enforced, which is never easy. Or perhaps Native Authority Rules? Yes again, provided you do not get too far ahead of African public opinion. It may be wise to start modestly; it is certainly well if it can be contrived that the pressure of wise propaganda is from within, not from without; to hasten slowly but to be sure of progress; to see that gradual progress does not deteriorate into apathy and inertia; to see that the interest is maintained.

It is certain therefore that losses due to fire are tremendous, mostly outside forest reserves, although one forest officer estimated that in one year 5 per cent by area of his all too exiguous forest reserves had been affected. Equally certain is it that there is no heaven-sent remedy, no panacea. To combat innate practices, the habits of centuries, is no easy matter. The whole landscape going up in smoke annually drew the very first comments of the very earliest explorers and radical change cannot be accomplished in one or perhaps in many seasons. Better means of organized fire prevention must be found, better pastoral habits instilled in the African peasant and more permanent agriculture encouraged.

You must encourage early burning, say some, but though by no means a mere shibboleth, this phrase covers a multitude of practical difficulties. Grasses in any one area are many in number, different in habit, in the methods of their regeneration which may be by seed or stolon, and in their flowering seasons. By assuring the destruction of one bad grass you may equally assure the survival of a worse, and the multiplicity of grass species may cause a bad burn which may necessitate going over the area more than once.

The Conservator of Forests, Tanganyika, wrote a rather lengthy memo in 1946 summarizing what he considered were desirable measures to mitigate the fire damage. First he placed the rousing of the public conscience in all communities to the dangers. Next it was considered necessary to involve as many members of these communities as deeply as possible first in the work of prevention. For example, the many forest fires of early 1946 were so obviously destructive that in quick time it was possible to take steps to prevent honey collection in a traditional but dangerous manner in three adjacent districts. It remains to be seen whether it will be possible to enforce such measures.

The Grass Fires (Control) Ordinance is useful but perhaps does not go far enough even when fortified by a legal ruling that growing crops can be interpreted to include standing forest. Other suggestions were the grant to peripheral forest dwellers of cultivation rights on a narrow strip of forest in exchange for the obligation to exclude fire or to fight it should it enter, the planting of dangerous grass glades in the forest with mostly pole or fuel crops on similar conditions; the planting at the tree line of fire-resistant species. Early burning was recommended as the general policy when accepted with due reserve where it can be accomplished efficiently, and it can in many districts, if correlated with other interests such as grazing and the spread of tsetse. It is doubtful if the nomadic pastoralist will ever be an enthusiastic fire fighter, all his instincts being in the opposite direction, but for them pipe-borne water beyond the tree line will help and this is being arranged increasingly.

The response to the memo already mentioned was encouraging and it elicited helpful comment from many varied quarters. Let us hope therefore that the changing outlook towards this major problem of government will persist as it must if our forests are to be saved for posterity.

W. M. R.

GRASS FALLOW IN UGANDA

I—GRAZING DURING THE FALLOW PERIOD

By **R. E. Kerkham, Department of Agriculture, Uganda**

(Received for publication 24th April, 1947)

Use of the grass or bush fallow has been the traditional method of maintaining soil fertility in most parts of Uganda. Martin [1] and [2] has described experimental work which indicates that the grass fallow is a more efficient means of maintaining crumb structure than the use of annual green manures, fertilizers or organic manures. Describing recent results of the Serere Fertility Experiment, Martin and Biggs [3] show that crop yields bear a reasonably close relation to crumb structure measurements; what Martin calls the "market gardening effect" of fertilizers and organic manures in increasing crop yields is appreciable, but in no way invalidates his view that the grass fallow is the most certain and cheapest method of maintaining fertility in the majority of the soils of Uganda. This experiment, and others carried out at Serere, Ngetta and Kawanda, are now beginning to produce results which allow for evaluation of the various methods of maintaining fertility, and these results will be described in subsequent articles in this series.

Stock, both cattle and goats, are an important constituent of the agricultural system in many parts of Uganda. Randall [4] states that in parts of Teso there may be as many as eight head of cattle per taxpayer, and all resting arable lands are heavily grazed. In other parts of Teso, and in much of Lango, Mbale and north Busoga districts cattle occasionally graze on resting arable lands. In Buganda the number of cattle is increasing in certain areas, though resting land is seldom grazed. In all these areas it is essential to find out whether grazing of resting lands is desirable or not. An immediate answer to this question is of far more than academic interest. In many parts of East Africa there appears to be little doubt that stock are carried in greater numbers than is desirable for the maintenance of fertility. There was at one time a rather natural tendency to assume that similar considerations applied in Uganda, and suggestions for reducing the numbers of stock in certain areas, particularly Teso, have been made from time to time. Should experimental evidence indicate that grazing of resting land improves fertility, stock policy would take on an entirely different outlook. The major objective would be changed over from reduction of stock numbers to better distribution of stock in the heavily stocked areas; and increase in stock numbers in understocked areas. This paper describes evidence obtained comparing yields on grass land grazed during the resting period with those obtained after grass which was not grazed. This evidence has been obtained at Serere and Ngetta experiment stations, both of which are situated in the north-east short grass country of Uganda, where the average rainfall is between 50 and 55 inches, but the main dry season long and hot. Work has been started in the elephant grass country of Buganda, but no results have yet been obtained. No experimental work has been carried out in the dry sandy soils of North Teso and East Acholi, and there is no reason to believe that Serere or Ngetta results apply to these soils.

EXPERIMENTAL EVIDENCE

Ngetta Farm which is four miles from Lira in Lango district, was changed over in 1933 from continuous cropping with green manures to alternate cropping with three years cropped and three years rest under grazed grass. The farm consists of six 6-acre plots which have been treated in this way since that date. During most of the time the rate of grazing has been one beast per acre of resting land. Martin and Badcock [5] in 1937 considered that early results supported the view that grazing resting leys had improved subsequent crop yields. Though it is difficult to produce figures which eliminate the effect of seasons there can now be no doubt that the general level of fertility on the farm has improved appreciably. Yield levels are now far higher than the general level of native yields, whereas they were no higher in 1933.

Serere Experiment Farm.—Three 10-acre blocks on this farm have been farmed on a 3:3 rotation since 1934. They were periodically grazed from 1934-39. Since 1940 they have carried one beast to the acre of resting land. In the earlier history of this section of Serere Farm farmyard manure was applied. By 1941-42 the general fertility level had risen well above normal for the area, and it was considered advisable to stop manuring and to rely on grazed resting leys as the sole means of maintaining fertility. Yields have since been maintained at a very high level for this class of land.

Grazing Trials—Serere and Ngetta

A series of trials was laid down at Serere and Ngetta in 1941 and succeeding years.

Natural regeneration was compared with seeding down with Rhodes grass, *Chloris gayana*. In all cases land had been cropped previously for approximately three years. Natural regeneration under these conditions at both places in effect gives Giant Star grass, *Cynodon plectostachyum* on grazed land, as this grass is found in almost pure stand when resting land is grazed. When not grazed, Cotton grass, *Imperata cylindrica* is dominant by the second or third year at Serere; at Ngetta the dominant species is normally *Cynodon*. The Rhodes grass strain used was the local leafy strain at both centres.

Three grazing rates were also compared—

(*a*) No grazing;

(*b*) Light grazing;

(*c*) Heavy grazing.

In all cases treatment (*c*) had double the grazing rate of treatment (*b*) by putting double the number of beasts into (*c*) plots for the same period as on (*b*) plots. At Serere the heavy rate was four beasts for four days per month in half acre plots, i.e. 32 grazing days per month. At Ngetta the rate varied with the amount of grass available. Conditions at the two centres were not therefore exactly comparable and a combined analysis of results from the two centres might not be accepted by the purist, though they are near enough to ensure that major results are not upset by slight differences in treatment at the two centres.

At both centres replication of treatments has been obtained by repeating them in different years. At Serere there are four blocks, one laid down in 1941, two in 1942 and one in 1943; at Ngetta there are two blocks, one laid down in 1941 and one in 1942.

Full results of the experiment will not be obtained until rotation and treatments have been continued for several years yet, but preliminary results are sufficiently consistent to give an indication of what is likely to happen in the future.

The rotation used on these trials was:

First Circuit—

First, second and third years.—Resting. Treatments applied.

Fourth year.—Cotton.

Fifth year.—Finger millet followed by cotton.

Sixth year.—Various crops.

Second Circuit—

First circuit repeated.

Crop Yields—

Statistical analyses of figures given in both Tables I and II have been carried out. In neither case are differences significant. If similar figures are obtained in subsequent years there will be a better chance of obtaining significance. The figures show no sign that grazing has decreased soil fertility, which is the really important point so far as the farmer is concerned. They also suggest that seeding down with Rhodes grass may be preferable to allowing grass to regenerate naturally.

Grazing Trial: Ngetta (1936).

This experiment was laid down at Ngetta in 1936 to compare two sets of treatments.

(i) Grazing versus No grazing;

(ii) Comparisons between different grasses.

The effects of grazing versus no grazing only is discussed here. The experiment was opened to cropping in 1939, and yields obtained are given in Table III.

Pigeon peas sown with Finger Millet in the first rains of 1940.

Sesame intersown in standing Pigeon peas.

Cotton yield: lb. seed cotton.

Finger Millet yield: lb. unthreshed heads (grain averages 75–80 per cent).

Pigeon pea (*Cajanus cajan*): lb. threshed grain.

Groundnuts: lb. unshelled nuts (shelling percentage averages 60 per cent).

In this case grazing produced a significant decrease in cotton yield in the first year of cropping, but there was no sign of any decrease in subsequent crops. Mr. G. D. Badger was Agricultural Officer in charge of Ngetta in 1939 and noted in his report of the experiment that growth was much more vigorous on the grazed plots than on ungrazed.

TABLE I

COTTON.—TOTAL SEED COTTON IN LB. PER ACRE

TREATMENT	Ngetta I 1944/45	Ngetta II 1945/46	Serere I 1945/46	Serere II 1946/47	Serere III 1946/47	Mean
Chloris						
No grazing	343	802	384	644	480	531
Light grazing	407	668	520	558	578	546
Heavy grazing	444	790	536	572	588	586
Mean	398	753	480	591	549	554
Natural Regeneration						
No grazing	488	418	426	714	350	479
Light grazing	421	569	506	856	288	528
Heavy grazing	372	694	468	610	382	505
Mean	427	560	467	727	340	504
Combined	Chloris	Natural Regeneration	Mean			
No grazing	531	479	505			
Light grazing	546	528	566			
Heavy grazing	586	504	545			
Mean	554	504	529			

TABLE II

FINGER MILLET YIELDS—UNTHRESHED HEADS PER ACRE

Fifth Year of the Rotation

TREATMENT	Ngetta I	Ngetta II	Serere I	Mean
Chloris				
No grazing	2,573	2,059	1,528	2,053
Light grazing	2,965	2,410	1,676	2,350
Heavy grazing	2,280	2,643	1,828	2,250
Mean	2,606	2,371	1,677	2,218
Natural Regeneration				
No grazing	1,975	1,652	2,092	1,906
Light grazing	2,503	1,795	1,614	1,971
Heavy grazing	2,884	2,280	2,014	2,393
Mean	2,454	1,909	1,907	2,090
Combined Results				
No grazing	2,274	1,855	1,810	1,980
Light grazing	2,734	2,102	1,645	2,160
Heavy grazing	2,582	2,461	1,921	2,321
Mean	2,530	2,140	1,792	2,154

TABLE III

YIELDS IN POUNDS PER ACRE

	1939/40 Cotton	1940 Finger Millet	1940 Sesame	1940 Pigeon Pea	1941 Groundnuts
Grazed	287	1,704	Failed	505	1,712
Ungrazed	397	1,515		466	1,702
L.S.D. P = 0.05	48	Nil		Nil	Nil

The general fertility status of Ngetta farm is high, and an occasional case of excessive vegetative growth under high nitrogen status produced by heavy grazing is not unexpected.

Ngetta:—Soil Rejuvenation Experiment (1939)

This experiment was started in 1939 on land which was then commencing its three years rest under grass. It was laid out in four blocks of four plots and treatments were:—

1.—(*a*) Natural regeneration. Grazed.
1.—(*b*) Natural regeneration. Ungrazed.

2.—(*a*) Seed mixture. Grazed.
2.—(*b*) Seed mixture. Ungrazed.

The seed mixture used was 20 lb. per acre each of Rhodes Grass, *Chloris gayana* and Golden Timothy, *Setaria sphacelata* with *Brachiaria decumbens* planted at 2 ft. x 2 ft.

SERERE—FERTILITY EXPERIMENT

The cover crops used during the resting period in this experiment in the first circuit were:—

(*a*) Natural Regeneration;

(*b*) Planted Grass (*Cynodon*);

(*c*) Green Manure (*Mucuna*): slashed;

(*d*) Planted Grass (*Cynodon*): slashed;

(*e*) Green Manure (*Mucuna*): dug in.

Treatment (*d*) was intended to imitate grazing. In the second circuit of the experiment slashing of *Cynodon* in treatment (*d*) was replaced by grazing, and first results are now beginning to come in. Yields of cotton given in Table IV were obtained in the first year after rest.

TABLE IV

CROP YIELDS (LB. PER ACRE)

CROP AND YEAR	1.—(*a*)	1.—(*b*)	2.—(*a*)	2.—(*b*)	Mean Grazed	Mean Ungrazed	Mean Seeds Mixture	Mean Natural Regeneration
1942 Cotton ..	573	527	585	576	579	552	550	580
1943 Finger Millet	2,085	2,057	2,295	1,949	2,190	2,003	2,071	2,122
Sesame ..	31	15	80	40	55	28	23	60
Pigeon Pea	248	197	189	232	219	214	222	211
1944 Groundnuts	1,727	1,839	2,102	1,812	1,914	1,826	1,783	1,957
Sorghum ..	1,071	1,110	1,165	1,101	1,118	1,106	1,091	1,132

The experiment was opened to cultivation in 1942 when *Cynodon* was dominant in all grazed plots. Very little *Setaria sphacelata* germinated.

Yields are:—

Cotton: Total seed cotton per acre;

Finger millet: Unthreshed heads per acre;

Sesame: Threshed grain per acre;

Pigeon peas (*Cajanus cajan*): Threshed grain per acre;

Groundnuts; Unshelled per acre;

Sorghum: Unthreshed heads per acre.

In the second year, according to Lango custom, pigeon peas were sown with the finger millet and sesame sown in the standing pigeon peas after harvesting the millet.

In no case are differences significant but indications are:—

(i) That grazing was not inferior to no grazing.

(ii) That the seeds mixture used in this case was not better than natural regeneration.

TABLE V

TOTAL SEED COTTON IN LB. PER ACRE

Treatment	Yield
(*a*) Natural Regeneration	625
(*b*) *Cynodon* : Ungrazed	604
(*c*) *Mucuna* : Slashed	596
(*d*) *Cynodon* : Grazed	733
(*e*) *Mucuna* : Dug in	638

A full analysis has not yet been done but (*d*) will undoubtedly be highly significantly higher than (*b*). In previous years, when the comparison was between slashed and unslashed *Cynodon*, there has been no difference between (*b*) and (*d*).

SUMMARY

Experiments are described which compare the fertility of land grazed during a grass fallow period with grass fallow ungrazed. Though no one experiment has given results which are statistically significant all results are consistent and show that fertility after grazing is certainly not lower than without grazing under these conditions.

Comparisons between seeded leys and natural regeneration have not given consistent results, though there are indications that Rhodes grass, *Chloris gayana* is worth sowing.

The experiments were carried out at Serere and Ngetta experiment stations, both stationed in the north-east short-grass area of Uganda where rainfall is fairly high, but the annual dry season is normally fairly long and hot.

PRACTICAL IMPLICATIONS OF THIS EXPERIMENTAL WORK

Results are sufficiently conclusive to warrant encouraging farmers in areas of which these stations are typical to graze resting leys wherever possible. Though fenced paddocks are probably not an economic proposition today in much of this country, much could be done by improving the layout of village lands so as to allow the best chance of herding cattle on resting land without damaging growing crops.

BEARING OF THIS EXPERIMENTAL EVIDENCE ON FUTURE EXPERIMENTAL WORK

In the "Short Grass Country" the way has now been cleared for work to determine the best method of managing resting leys. The main aspects of this problem which need to be answered are;—

> The best grass species or mixture of species for various conditions. Grazing management, including time to start grazing, deferred and rotational systems, grazing intensity, and the effect on the animal as well as the soil.

A start has been made on many of these problems, but these could not be considered of major importance until the fact had been established that grazing maintains fertility at least as well as an ungrazed fallow.

Though dry sandy soils are not of major economic importance in Uganda they cover considerable areas in Acholi, North Teso and Karamoja, and are very important in parts of Tanganyika and Kenya. These soils have little crumb structure in Dr. Martin's sense, and there is considerable evidence that Serere and Ngetta results do not apply to them. Complementary work is required in these areas.

Serere and Ngetta results do not apply to the "Long Grass Country" of Buganda and the Lake area, nor to hill country of western Uganda or Bugishu. Work along the same lines has been started in these areas, and it is already obvious that very different factors are involved. For example control of Blue Couch Grass, *Digitaria scalarum*, is a major factor in these areas, and high population intensities, and high land values in some cases, make the utilization of farmyard manure a far more promising proposition.

ACKNOWLEDGMENTS

The work described has been carried out by many members of the department stationed at Serere and Ngetta during the past 15 years. Messrs. E. Williams, W. J. Badcock, T. McEwen, J. M. Watson, G. D. Badger, R. P. Davidson and the writer have been mainly concerned with conduct of the field work, but many other officers of the department have given advice and helped with supervision from time to time. Much of the work is a logical extension of Dr. Martin's work [1] on crumb structure. Opinions expressed are those of the writer. I am indebted to Mr. H. L. Manning for reading through the typescript and making numerous suggestions and amendments.

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MAHOGANY IN EAST AFRICA

I—THE KHAYAS

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According to the *Shorter Oxford English Dictionary* the name mahogany, written "mohogeney" in 1671, is of unknown origin and is applied to a dark coloured wood used for furniture. The true mahogany is derived from members of the genus *Swietenia* of which there are five species, *S. mahagoni*, Spanish mahogany, a native of the West Indies; *S. macrophylla*, Honduras mahogany, found in Central America; *S. candollei*, Venezuelan mahogany; *S. humilis*, Mexican mahogany; and *S. krukovii* from Brazil. These are members of the Meliaceæ and from two of them, *S. mahagoni* and *S. macrophylla*, was obtained the mahogany timber so popular in the Victorian era for furniture and cabinet-making.

The value of mahogany as a timber was first observed by a carpenter on board Sir Walter Raleigh's ship in 1595, who noted its great beauty, hardness and durability, but it was used by Cortez as early as 1521 for repairing and even for building ships for further voyages of discovery after his conquest of Mexico.

It was brought to notice, as well as adapted for furniture, by a Dr. Gibbons in the early part of the 18th century. Its use as a cabinet wood was first practically established by the cabinet-maker Wollaston, who was employed by Gibbons to work up some mahogany brought to England by his brother. The beautiful furniture produced by the superb artists and craftsmen Chippendale, Heppelwhite and Sheraton was almost entirely carried out in mahogany.

In the 1880's the demand for mahogany had exceeded the supply, and efforts were made to introduce and establish the species in tropical stations of the Empire. Kew played an important part in this by acting as a distributing centre for seeds. Some of the introductions were successful, especially that of *S. macrophylla* into India. Both *S. macrophylla* and *S. mahagoni* have been tried in East Africa, but the latter has not been a success, although *S. macrophylla* grows well in Entebbe and Kampala, Uganda. Strangely enough the Germans did not introduce any of the species into the Amani plantations, but it is on record that there was a solitary specimen of *S. mahagoni* in the Government Park, Dar es Salaam, in July, 1914.

At the same time that the Swietenias were being introduced into various parts of the world, a search for substitutes was made, and by 1890 there were considerable quantities of so-called mahogany from West Africa on the British market. This West African mahogany is derived from species of *Khaya* and *Entandrophragma*, both closely related botanically to the Swietenias.

The name mahogany has been applied indiscriminately to nearly two hundred species of trees which are distributed between some thirty-seven families, including the Meliaceæ. This article deals only with the so-called mahoganies of the genus *Khaya* in the Meliaceæ.

The genus *Khaya* was founded by the botanist A. Jussieu in 1830 [1] when he transferred a West African tree named and described *Swietenia senegalensis* by Desrousseaux [2] to the new genus.

The next species to be described was *K. anthotheca* under the name *Garretia anthotheca* by Welwitsch [3] in 1858, based on one of his specimens collected in primary forest in the Golungo Alto district of Angola. It was transferred to the genus *Khaya* by C. D. Candolle [4] in 1878.

From that date up to 1935 some seventeen species of *Khaya* have been described, of these fourteen are from West Africa, four occur in East Africa and one, *Khaya madascariensis*, in Madagascar.

Recent botanical research, however, has reduced this number to some ten species, and when further information is available it is possible that these will again be reduced. The ten species are: *K. anthotheca, K. canaliculata, K. caudata, K. grandifoliola, K. ivorensis, K. madascariensis, K. mildbraedii, K. nyasica, K. senegalensis and K. wildemanii.*

BOTANICAL CHARACTERS

The genus *Khaya* is composed entirely of evergreen or semi-deciduous trees ranging from 50 ft. to 180 ft. in height, with a girth of 10 to 14 ft. or more, or a diameter ranging from 3 to 8 ft. (in rare cases up to 15 ft.), not infrequently buttressed at the base up to 12 ft. from the ground. The leaves are alternate compound, abruptly pinnate, 6 to 20 inches long; the leaflets are 6 to 10, ranging from 2 to 6 inches long and about 1½ to 2 inches broad. The small flowers are white, borne in fairly large stiff or lax panicles towards the ends of the branchlets from the axils of the leaves. As originally described, the sepals and petals were four in number, but in some species they are arranged in fours or fives. The sepals are rounded, small and overlapping. The petals are twisted. There are eight or ten stamens, arranged in a short tube which is 8 or 10-lobed at the mouth, the lobes being rounded and entire; the anthers are included in the tube between the lobes. The ovary is four or five-celled, surrounded by a short, cup-like fleshy ring or disc, narrowed into the short style which is capped by a disc-like stigma. There are ten to sixteen ovules arranged in two series in each cell. The fruit is a globular, woody, brown, erect capsule about 2–2½ inches in diameter, and opens from the apex to the base by four or five lanceolate woody valves. The numerous papery brown seeds are flat and winged around the margins, roughly oblong or slightly kidney-shaped in outline, up to 1½ inches long by 1 inch broad.

FIELD CHARACTERS

The four species found in East Africa are: *Khaya anthotheca* (Welw.) C.DC. (Fig. 1), first recorded from Angola and known to extend into West Africa through the French Cameroons as far west as the Ivory Coast. It probably occurs in the Belgian Congo also, since it is found in Uganda and Tanganyika. In Uganda it is known as Uganda mahogany with the vernacular names of *Kirumbo* (Kuamba) and *Munyama* (Lunyoro). The trade name is African mahogany. In Uganda it occurs in the rain forests of Toro and Bunyoro, where it is a deciduous tree reaching a height of 150 ft. or more. The trunk is heavily buttressed to a height of 12 ft. and the bole is usually only moderately straight. The bark is described as fairly smooth, ashy-brown to very pale grey, flaking in small circular scales to give a characteristic pock-marked appearance; slash reddish-brown, a yellow gum-resin exuding. The parts of the flowers and fruits are usually arranged in fours. The fruit is held upright and is a globose, grey-brown, four-valved, woody capsule about 2½ inches in diameter; it is conspicuous on the crown of the tree and persists for a considerable time after the seeds have been shed.

Khaya grandifoliola C.DC. (Fig. 2) ranges from French Guinea to the French Cameroons and extends through the upper Ubangi and by way of the Eastern Sudan into north-western and northern Uganda and north-western Tanganyika. Like *K. anthotheca*, its trade name is African mahogany, and in Uganda it is known as big-leaf mahogany with the vernacular names of *Eri* (Madi), *Mario* (Lugbara), *Munyama* (Lunyoro) and *Tido* (Gang). It is a medium to large-sized deciduous tree found in riverine forest fringes in open bushland, with a bole up to 70 ft., usually with buttressed base, a somewhat crooked stem, a large branched rounded crown and a girth up to 14 ft. The bark is pale grey, fairly smooth towards the top of the bole but cracking into irregular scales towards the base; slash dark red with lighter streaks. The parts of the flowers and fruits are arranged in fives, and are borne in stiff panicles up to 1 ft. long. The fruit is five-valved about 2½ inches in diameter.

K. nyasica Stapf ex Bak. f., was originally described from the Lower Umswirizwi River and Chirinda Forest in Gazaland. It extends into the Transvaal, through Nyasaland and Northern Rhodesia into Tanganyika. It is found on rivers and streams, in rain forest, and in riverine fringes in open to closed bushland. In Gazaland its vernacular names are *Muwawa* (Chindao) and *Umbaba* (Singuni).* It is a semi-deciduous to evergreen tree attaining a height of 150 ft. or more, and in exceptional cases it may have a diameter of 15 ft. at 9 ft. from the ground, but diameters of 5 to 8 ft. are more usual. The bole is usually very straight above the buttresses and the crown is lightly branched. The bark is light grey, thick, smooth or flaking off in irregular patches. The flowers and fruits were not described, but a co-type in the Tsetse Research Department's Herbarium, Shinyanga, Tanganyika, has the parts of the flower arranged in fours.

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* Other vernacular names are:—

In Nyasaland, *Mbawa*; *Muwawa* (Chewa and Tonga).

Northern Rhodesia, *Mululu* (Wemba, Wisa, Chishinga, Yombe, Southern Senga, Kambonsenga, Tonga and Lenje); *Muwawa* (Tumbuka); *Mbawa* (Ngoni).

Tanganyika, *Mkangazi* (Swah.); *Mtondoo* (Bondei); *Mnyofu* (Kigoma); *Ilulu* (Kyimbila); *Mbulu* (Nyika); *Nyaelasi* (Rungwe); *Mtembo* (Ufipa) and *Mwawa* (Ulanga).

K. senegalensis (Desr.) A. Juss. (Fig. 3), was originally described from Senegal, West Africa. It extends from the French Sudan through the French Cameroons into the Eastern Sudan and north-west Uganda, and is found in open bushland and in riverine forest running through such country. In Uganda it is found only in the Achole, Madi and West Nile districts; its vernacular names are *Eri* (Madi), *Kiré* (Kakwa), *Mario* (Lugbara) and *Tido* (Gang). It is popularly known as Senegal mahogany. It is a deciduous tree 50–90 ft. high with clean bole 20 to 50 ft. long, and has only slight buttresses, if any, at the base; the girth ranges up to 10 ft. The widespreading branches form a rounded crown. The bark is grey with small thin scales, the slash is a bright crimson, a red sap exuding. The parts of the flowers and fruits are arranged in fours; the flower has a red disc around the ovary. The flowers are borne in lax axillary panicles up to 8 in. long, in the axils of the leaves towards the ends of the branches. The fruit is globose, about 2 in. in diameter, erect and conspicuous on the tree.

CHARACTERS OF THE TIMBERS

Khaya anthotheca, Uganda mahogany or munyama, is pale pink when freshly cut but darkens with exposure to a light mahogany colour rather variable in tone, sometimes almost a light brown. When freshly cut the sapwood does not differ much from the heartwood, but remains lighter coloured and browner in seasoned wood. The grain usually interlocks and is seldom straight; it is sometimes wavy and has a "figure", but then only in small areas. Its weight ranges from 33 to 35 lb. per cubic foot at 14 per cent moisture content (about 44 lb. in the green state). The wood has a tendency to split at the ends as it comes off the saw, but this can be overcome to some extent by nailing strips of wood across the ends of the boards. The timber can be kiln-seasoned fairly rapidly from the green or air-dried state with very little degrade, or by air seasoning if gloss oil is applied to the ends of the boards.

Its working qualities are relatively good, as it can be worked fairly readily with hand or machine tools, and it has little dulling effect on cutting edges. When clean and straight grained, it finishes to a moderately good surface, but with an interlocking grain it has a tendency to "pick up", particularly in quarter-sawn timber and in the vicinity of knots where cross-grain occurs.

Tests in the ground in Uganda have shown its durability to be comparatively low, although it is more resistant to fungal decay than the heart-wood of Scots pine, it is much less durable than the heart-wood of English oak.

Logs are susceptible to attack by pinhole borers and longhorn beetles, while seasoned sapwood is liable to infestation by powder-post beetles of the *Lyctidæ* and *Bostrychedæ*. It is not resistant to termites.

The timber is suitable for superior joinery, decorative furniture, cabinet-making, handrails, mouldings, turnery and for good class plywood.

K. grandifoliola, big-leaf mahogany, is so little known in Uganda that its local importance is small at present. The wood is pink when freshly cut, but darkens to a moderately deep mahogany tone; the sap-wood remains lighter coloured and in the seasoned condition is readily distinguishable from the heart-wood. The bushland-grown wood is usually darker than that from the forest. It weighs 48 lb. per cubic foot at 15 per cent moisture content, is moderately stiff and hard and does not split readily. Little is known about the seasoning of this timber, but it seems to dry very well with hardly any twisting or degrading.

It resembles true mahogany, *Swietenia* spp. more nearly than any of the other Khayas, although it tends to be heavier, particularly that from open bushland. It is very suitable for cabinet-making and decorative joinery, requiring considerably less filling than Uganda mahogany; its uses include veneering and panelling. For carpentry and joinery this timber has excellent working qualities, giving good results with all tools, and it takes a very high polish without excessive filling. Little is known of its durability.

K. nyasica, when fresh this timber is almost pink, but when dry it has a typical mahogany reddish-brown colour with a natural lustre. It is only moderately hard and usually has a wavy grain, although this may be straight; its air-dry weight is about 36 lb. per cubic foot. It air-dries rapidly without undue distortion. The timber saws easily, but planes a little hard with a tendency to "pick up" which can be prevented by using sharp cutters set at an acute angle. It finishes to a splendid polish, is easy to mortise, recess and mould, but will not bend well. It splits a little when nailed close to finished edges. It can be used for cabinet-making, furniture, joinery, turnery, interior fittings, panelling, boat-building and for veneering.

K. senegalensis, Senegal mahogany, is pale pink-brown when freshly cut, darkening with exposure to a rather deep mahogany colour. The sap-wood is scarcely distinguishable from the heart-wood, being only slightly paler and browner, and the stripe or roe, characteristic of timber with interlocking grain, is often very marked. It is moderately heavy, weighing about 48 lb. per cubic foot at 15 per cent moisture content, and is moderately hard and stiff. Little is known about seasoning it, but care is needed to prevent warping and splitting. In its working qualities it gives satisfactory results with all tools, but is not as easy to work as Uganda mahogany because it is considerably harder. Experiments in the Sudan show that the timber is particularly resistant to termites, but in Uganda it is recorded as not being very durable in the ground, though more so than *K. anthotheca* and *K. grandifoliola.*

This timber was probably the first mahogany exported from West Africa on a commercial scale, as 250 tons were shipped from the Gambia River to Liverpool in 1886. In Uganda it is very little known, and where exploited has been used only for temporary buildings and rough furniture. In the Sudan it has been used for the usual purposes to which mahogany is put, including railway carriage construction and for sleepers. It is considered to be the densest and hardest of the Khayas, but these qualities vary with the locality of growth, that from dry and arid habitats producing the densest timber, which is quite often dark in colour and generally resembles Spanish mahogany (*Swietenia mahagoni*) more closely than any other African species. Those trees associated with *K. grandifoliola* in riparian forest have a timber which is milder and resembles this species.

AFFORESTATION

The Khayas should be considered for afforestation by forestry departments and by those wishing to re-afforest areas that have been under forest. *K. anthotheca* is a rain forest and riverine species requiring a fairly well distributed annual rainfall of about 70 in., *K. grandifoliola* and *K. nyasica* are mainly riparian species and may not require such a high rainfall. *K. senegalensis* will stand a drier climate; it is normally riparian but often grows gregariously in clumps of a dozen or more trees closely spaced together on the margins of seasonally flooded valleys. Scattered individuals may also occur.

The altitudinal ranges of the Khayas appears to be from about 800 ft. to 4,000 ft., *K. nyasica* having the greatest range. An altitude of 3,000 to 3,700 ft. seems to be the optimum for *K. anthotheca* in Uganda; about 3,500 ft. is the optimum for *K. grandifoliola* and possibly 2,000 to 3,500 ft. for *K. senegalensis.*

K. anthotheca and *K. grandifoliola* show fair natural regeneration, that of *K. nyasica* does not appear to have been observed, whilst that of *K. senegalensis* is recorded as poor, though its spread could perhaps be facilitated by protecting the young regenerating plants from grass and bush fires. In Nigeria *K. senegalensis* reproduces by suckers, but such a mode of reproduction has not been observed in Uganda.

Old stems of *K. anthotheca* and *K. grandifoliola* do not coppice, but with both species coppice growth is produced readily from young stems and stools.

The number of seeds per lb. has not been recorded for *K. nyasica.* The seeds of *K. grandifoliola* are the largest and heaviest of the other three species, there being approximately 1,700 per lb. *K. anthotheca* has about 1,800 per lb. and *K. senegalensis* has the lightest seed, 2,200 per lb.

As the seeds do not retain their viability for very long, and if stored are soon attacked by borers, they should be sown at a depth from ½ to ¼ in. as soon as possible after collecting, the beds being lightly shaded.

K. anthotheca should germinate over a period of eleven to twenty days, maximum germination taking place between thirteen and sixteen days. *K. grandifoliola* takes eight to 21 days, the maximum occurring at fourteen days. There are no published dates for

K. nyasica, but *K. senegalensis* takes ten days with a maximum of eighteen days. If the seeds are in good condition they should give a germination rate of 80 to 90 per cent.

The seedlings can be transplanted when they are three inches high, that is about three to four months after sowing. Transplants are not as successful as stump plants or tall stopped plants 5 to 6 ft. high, and if this latter type of plant is used the seeds should be spaced wide apart in the beds to avoid later transplanting. The seedlings can be kept in the beds for eighteen months to two years before stumping or stopping preparatory to planting out.

Open-grown Khayas are liable to sun-scorch and to attack by a shoot-borer and a gall-fly. The latter attacks the leaves, particularly those of *K. anthotheca.* Natural seedlings are less likely to be attacked by the shoot-borer, *Hypsipyla,* than are plants which have been transplanted from nursery beds to forest clearings, and in order to avoid heavy damage by this borer the Khayas should be interplanted with fast-growing species. In Nigeria, a pure stand of *K. senegalensis,* planted 6 ft. by 6 ft., proved a failure; the shoots were badly bored and there was rapid invasion by grass. Trials are now being carried out there with closer spacing and interplanting with other species. In Togoland a mixture of *Khaya* with *Erythrophleum guineense* and teak, *Tectona grandis,* was found to be satisfactory, but in East Africa it is probable that *Khaya* would outstrip both these and thus be open to borer attack.

Young *Khaya* plants first produce a quick growing shoot, often over a foot long, and then rest for a month or two for the shoot to thicken and harden before height growth is resumed. It is during the sappy growing stage that the shoots are attacked by borer, as the insect lays its eggs just behind the growing point.

Figures for the growth rates in East Africa of the four species of *Khaya* described in this paper have not been published.

The formation of growth rings has been studied in *K. grandifoliola* from the Gold Coast, but it was not possible to correlate their formation with seasonal periodicity of growth, as the growth rings were often discontinuous.

In 1914 the Germans recorded at Amani the growth rate of some 3,600 trees of *K. senegalensis* (since proved to be *K. anthotheca*). These trees were then ten years of age, 50 ft. in height and 2 ft. 4 in. in circumference. They were growing at an altitude of 2,500 ft. on the mid-slopes of a steep-sided and deep valley. The history of these trees is, that the first trial was made in 1903-4, when a *Khaya,* thought by the Germans to be *K. senegalensis,* was found growing in the Sigi Valley, near Amani, about 1,200 ft. above sea level. Its seeds gave a very good germination in the nursery and 50 young plants were planted out. Further collections of seeds were made and young plants were planted out in April, 1904, October, 1905, March and November, 1906. They were planted in plots ranging from 1,200 ft. to 3,000 ft. in the different plantation blocks of Amani, and of those still in existence to-day the biggest stands are growing at about 1,200 and 1,600 ft.

These two plots were sampled in April, 1947, when ten random trees in each plot were measured for their girth and height and the figures are given in the following table:—

PLOT 1		PLOT 2	
Girth at 3 ft. from the ground	Height	Girth at 3 ft. from the ground	Height
ft. in.	ft.	ft. in.	ft.
3 5	70	2 10	45
3 7	60	2 11	70
4 1	70	3 2	70
5 7	70	3 11	65
5 8	70	5 6	65
5 9	70	5 8	75
5 10	65	5 10	70
5 10	65	6 9	65
6 5	65	7 3	70
7 7	80	8 5	75

Both plots were on the slopes of very steep-sided and deep valleys; the trees were planted in pure stands at a spacing of 10 ft. by 10 ft. Those in Plot 1 at about 1,200 ft. altitude, were planted in November, 1906; the floor cover is the grass *Panicum trichocladum.* Plot 2, at about 1,600 ft. altitude, was planted in March, 1906; it has a mixed bush undergrowth.

NATIVE USES

In East Africa the Khayas do not seem to be used much by the Africans. *K. anthotheca* is said to have roots which are toxic; its bark is bitter and used for fever in Angola. The wood of *K. grandifoliola* is used for making canoes in West Africa and Ubangi. In the West Madi, Uganda, the bark is used as a

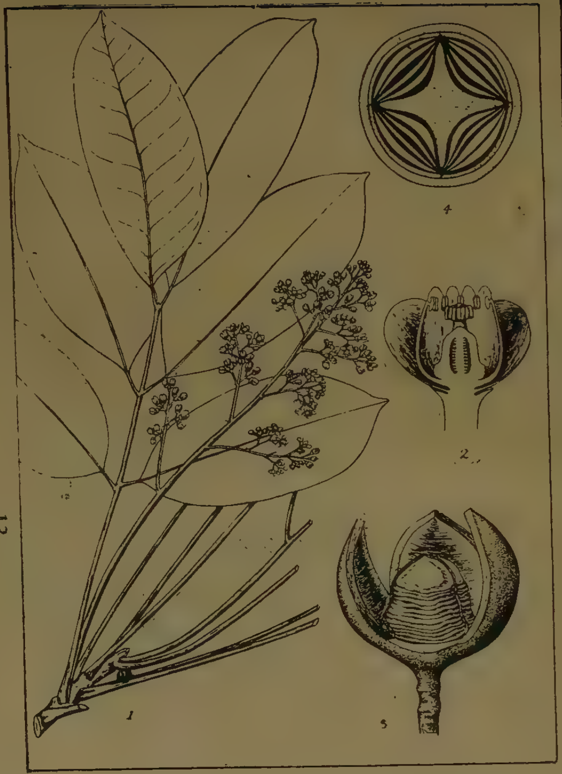

FIG. 1.—KHAYA ANTHOTHECA C.DC.

1. Flowering branch (½ nat. size).
2. Flower in vertical section, × 5.
3. Fruit (½ nat. size).
4. Diagram of fruit in cross section (½ nat. size).

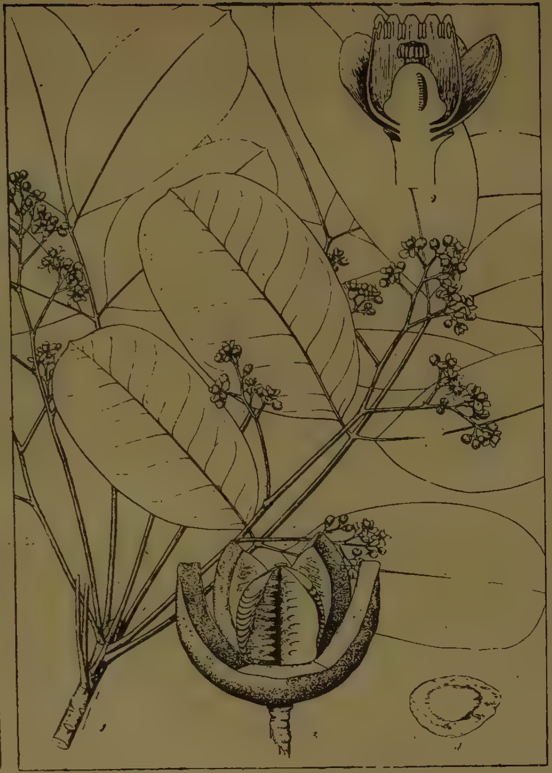

FIG. 2.—KHAYA GRANDIFOLIOLA C.DC.

1. Flowering branch (½ nat. size).
2. Flower in vertical section, × 5.
3. Fruit (½ nat. size).
4. Seed (½ nat. size).

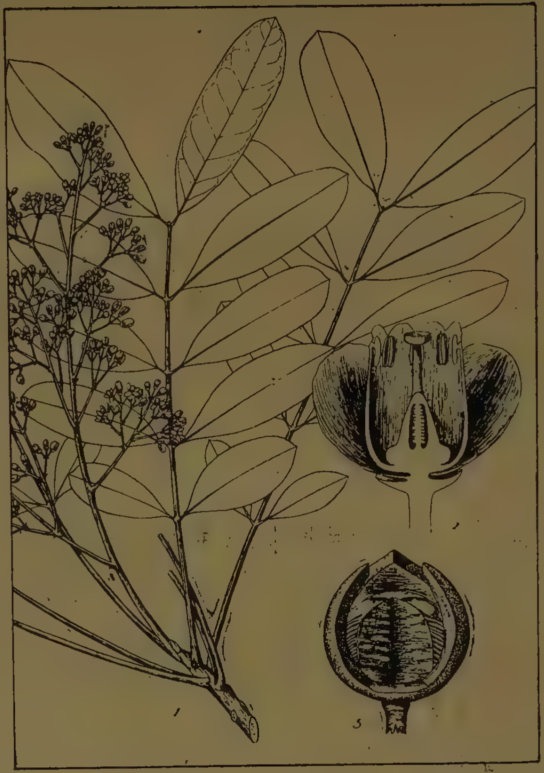

FIG. 3—KHAYA SENEGALENSIS A. JUSS.

1. Flowering branch (½ nat. size).
2. Flower in vertical section, × 7½.
3. Fruit (½ nat. size).

(Reproduced from *Forest Trees and Timbers of the British Empire, IV, Fifteen Uganda Timbers,* by kind permission of The Imperial Forestry Institute, Oxford.)

fish poison, the bark being put inside a sheath of grass and the long grass bundle placed across the streams above the pools.

In Tanganyika the bark of *K. nyasica* is boiled in water along with that of another tree and the resulting liquid is taken to cure colds. In Gazaland its seeds are crushed and boiled to extract the oil, which is said to have a bitter taste; this oil is rubbed into the hair to kill vermin.

In West Africa *K. senegalensis* is commonly used for mortars and furniture, also for canoes for which it is very good and durable; it also makes a very good charcoal. The bark of the latter has also many medicinal uses in West Africa, the chief being as a fever remedy; because of this it has been called "Quinquina du Sénégal". It is also employed in native veterinary practice. The flowers are also used for stomach disorders and as an ingredient in preparations for treating venereal disease. In Northern Nigeria pagan tribes extract the oil from the seeds of *K. senegalensis* by parching and boiling and use it as an unguent. The leaves are gathered and used as a cattle and camel fodder.

Bark of *K. senegalensis* from Northern Nigeria, examined at the Imperial Institute, gave no evidence of alkaloids, glucoses or of any resinous or crystalline neutral bodies. It did, however, contain 10.2 per cent of tannin and it is indeed used for tanning hides in parts of Senegal and Northern Nigeria.

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THE BANANA BORER

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INTRODUCTION

In 1824 a black weevil—one of the group of beetles whose heads are drawn out into a snout or proboscis—was described by Germar under the name of *Calandra sordida*, from "India orientali". What eventually proved to be the same insect was in 1845 called *Sphenophorus striatus* by Fahraeus, whose specimens came from Brazil. The name was changed to its present form, *Cosmopolites sordidus* by Chevrolat in 1885, who gave as its known distribution Brazil, Java; Ceylon, Malacca, Saigon, China, Réunion.

It is first mentioned in connexion with bananas by Fletraux and Salle in 1889 in their account of the beetles of Guadeloupe, as being common in rotting bananas. But it was not until 1906 that it was regarded as a pest of bananas, and an account given of its destructive powers on the Island of Sao Thomé in the Gulf of Guinea. It appears to have been observed as a pest about the same time in localities as far apart as Madagascar and Fiji, so that there is no indication of where it originated or how it spread, except that it probably moved around the tropics with the edible banana as it was spread by man from its original home in the East Indies.

On the African Continent it was first observed in the lower Congo in 1913. Next comes Gowdey's report of it in Uganda in 1918, with his opinion that it is not of recent introduction. Though not recorded by the Germans in Tanganyika prior to 1914 it was found to be well established at Amani by A. H. Ritchie in 1922. By 1936 banana weevil had been recorded in most parts of Uganda. Four years later it was found established in the adjoining Bukoba district of Tanganyika and on islands in the extreme south of Lake Victoria. In 1945 the writer identified specimens of the pest from Zanzibar, and, in the following year, from the Kilimanjaro area of Northern Tanganyika. In the same year it was stated to be generally distributed in the French West African colonies.

A considerable time elapses between the first arrival of *Cosmopolites* in a new area and its becoming a serious pest. Hargreaves (1940) estimated that this took about ten years in Uganda.

NOTES ON THE DAMAGE

The banana borer lives in the rhizome or "bulb" of the banana plant. The young grubs destroy a considerable amount of tissue by eating their way in irregular tunnels through the rhizome. In the case of older plants, this reduces their vitality and resistance to drought, causing poor bunches of fruit to develop on stems too weak to resist high winds. The suckers developing in a heavily infested stool are weakly and slow growing, thus interfering with regular cropping.

Young plants, especially suckers newly set out, are seriously affected by borer attack as they are not in a position to replace damaged root tissues as fast as the borer destroys it. So they are stunted, and ultimately the roll of unopened leaves goes yellow, withers and dies.

Depending on the degree of infestation by borer, a banana garden will become progressively less productive as general conditions of cultivation deteriorate. Vigorous stools support quite a high population of borers without visible effect, but given a drought, a reduction in soil fertility, or faulty cultivation and the bananas will show a disproportionate distress. The establishment of new gardens is more difficult in localities where borers are abundant. In other words the importance of the banana borer depends on suitability of the climate and soil for banana growing, and to the degree in which careful cultivation is employed to make up for any deficiencies in either of these respects.

LIFE HISTORY AND BEHAVIOUR

The borer has four distinct stages of development—(1) the egg, (2) the larvæ or grub, (3) the pupa, and (4) the adult weevil.

The egg is 1/12th in. in length, oval in shape and white in colour. The female weevil makes minute cavities near the base of a leaf in a growing plant, or in the side of a piece of cut stem on the ground and deposits her eggs singly in them.

The grub hatches out in from five to eight days depending on the temperature, and immediately starts to bore deeper into the rhizome or other tissues. Here it feeds and grows for two to three weeks. Fully fed, the grub is half-an-inch long, smooth, fleshy, legless, and white with a conspicuous red-brown head.

The pupal or dormant stage lasts for five to seven days during which time the colour darkens slightly as the insect beneath its outer skin changes into adult form and takes on a brown colouring.

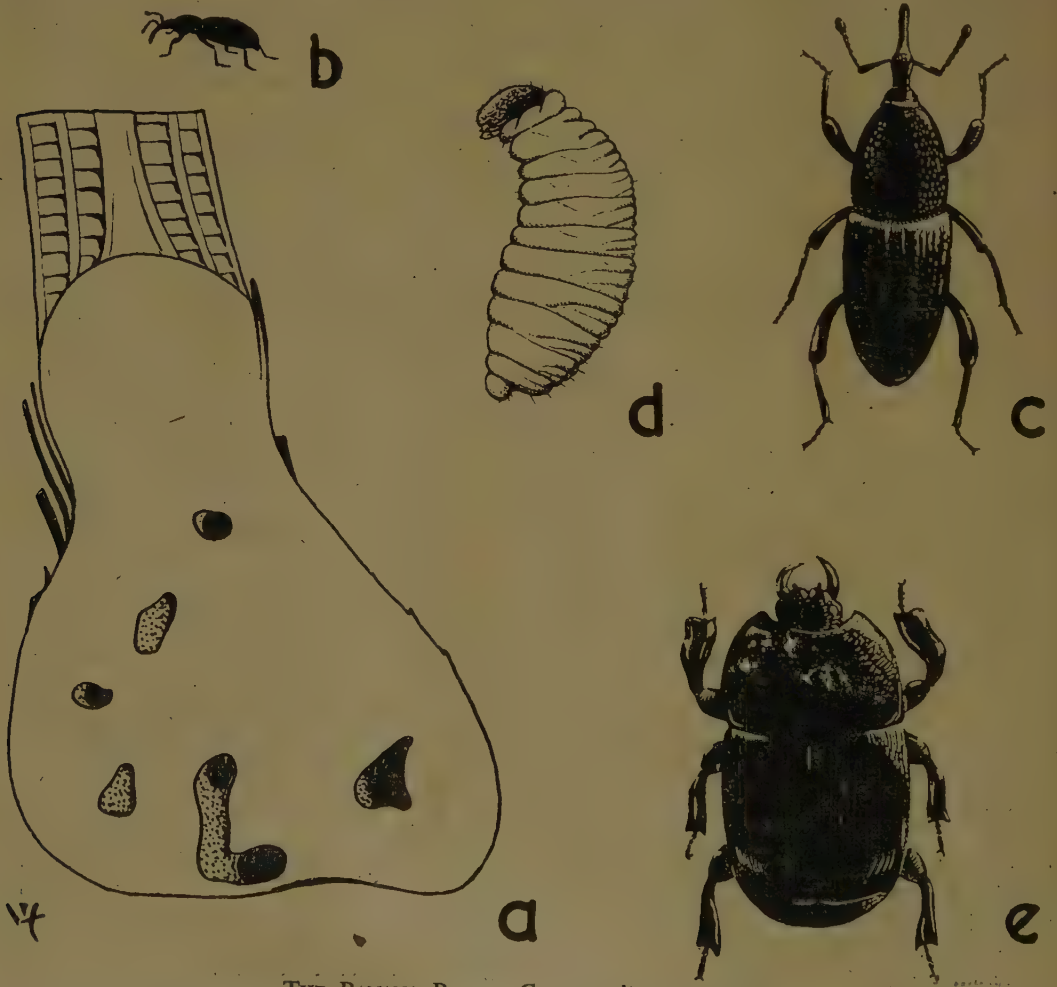
The weevil emerges, soft and brown, from the pupal skin and remains quiescent within its tunnel until its skin hardens and becomes almost black. It is half-an-inch long. Then it eats its way out to the surface, and takes shelter in the ground or under trash. It is a sluggish insect and is most active during the hours of darkness.

The time taken from one generation to the next is approximately a month under favourable weather conditions. It is believed that the adult banana borer can live two years.

Though the adult borer has wings there is little evidence that flying is a normal habit. In Fiji experiments indicated flight on warm humid nights at certain seasons of the year, but in New South Wales [Wallace, 1938] this could not be demonstrated and the spread of marked weevils collected in traps appeared to be comparable with walking ability only. Other results of the New South Wales experiments on migration showed that weevils had a fair range and frequency of movement between contiguous stools but that a strip of *Paspalum* grass varying from 12 to 24 yards wide proved an almost complete barrier to migration into an uninfested banana plot.

CONTROL

The obvious first step for the control of banana borer is to ensure that when planting suckers they are not already infested with grubs. Suckers should be dug up as required



THE BANANA BORER, *Cosmopolites sordidus*
(*a*) Section through a rhizome showing borer tunnel; (*b*) the adult borer, natural size; (*c*) adult borer × 3; (*d*) borer grub × 3; (*e*) the predatory beetle *Plaesius javanus* × 3.

for planting and not allowed to lie about overnight and act as bait for weevils. They should be freed from rotting sheaths where weevils might be hidden and then carefully examined for borer tunnels: paring away a thin layer of the rhizome will remove any eggs recently laid and expose any tunnels. Suckers showing extensive tunnelling should be discarded.

Planting the suckers with care so that they grow rapidly is the next step to avoid borer damage. Wallace [1938] has demonstrated in Queensland how planting suckers in holes six inches in diameter with unbroken sub-soil, followed by no weeding or tillage resulted in most of them being destroyed or seriously damaged in six months, while adjacent plants that had gone into holes twelve inches square with the sub-soil loosened and were kept free from weeds were all healthy and well developed.

Care of the banana field is generally recognized as being the main factor in borer control. According to Edwards (1934) in Jamaica "on most banana lands where a relatively high standard of cultivation is practised and wherever reasonable attention is given to field sanitation, the borer does not perceptibly affect fruit production", and that while "under complete economic control on the estates where a high standard of cultivation is practised, it is still very abundant where bananas are not grown intensively, as little or nothing is done under such conditions to combat the pest". Tillage and weeding are of primary importance throughout East Africa and with the establishment of a good mulch are all measures essential to maintaining the vigour of the bananas. As Smith (1939) has found in Australia, while some insects attack plants irrespective of their vigour, it has now been established that the susceptibility of a banana to weevil attack is largely determined by its vigour. To prevent the borer population reaching a dangerous level attention must be given to the regular removal of breeding places after a bunch has been taken. The spent stem requires to be cut off as near the ground as possible, and not left to rot in situ. In localities where it is the custom to leave these stems to help the growth of the next sucker, or to plant out suckers with a piece of old stem attached, they should have their tops sliced off as they start to rot, and the pieces buried. Old stems lying about will provide breeding places if not split up.

When suckers are removed from a stool or a rhizome cut for any other purpose, the cut surface must be covered with soil and not left exposed to attract weevils. Pieces of old rhizome removed in trimming a stool should be split up into small pieces.

Trapping borers is practised in many parts of the world. It is a useful addition to good cultivation if carried out with reasonable care. Pieces of well grown stems are used to attract the weevils, and may be either slices across the stem about three inches thick or else pieces of stem split lengthways and 18 in. long. These baits are placed on the ground in or beside a stool and covered with trash. They are left in position for three weeks and then removed and destroyed together with the weevils they have attracted. Fresh pieces of stem are then placed in the same position. They must not be forgotten, otherwise they will simply provide additional breeding grounds and aggravate the position. Baits inspected weekly can be used to obtain some idea of the degree of infestation in a banana garden. It is a waste of time to bait as a control measure in gardens where bananas are otherwise neglected. Good results have been obtained in Jamaica [Edwards, 1934], Congo Belge [Steyaert, 1944], and Queensland [Wallace, 1938].

A banana grower should not be discouraged from taking steps to reduce weevil attack on his land because his neighbours' gardens are neglected. Nor should this be used as an excuse for failure to have kept a banana garden in good heart. As Edwards told the Jamaica banana growers: "Contrarily to what planters generally believe by making wrong analogies with other agricultural insect pests which have different habits and biological peculiarities, the banana borer is not one of those pests which suddenly burst into plantations and effect much damage in a short time. When the borer population of a district or of a particular field is observed to be abnormally high, this should not therefore be ascribed to sudden outbreaks nor to mass migration from distant foci. An abundance of the pest in a field is the result of a cumulative increase of the insect population in the field itself or in the immediate vicinity during several generations and this indicates that measures of control have been inadequate during relatively long periods and that field hygiene has not been judiciously practised". At the same time concerted action by all the growers in one locality will produce a better return for the labour and more permanent results.

BIOLOGICAL CONTROL

The idea of controlling an insect pest by introducing natural enemies is an attractive one. It is most likely to succeed in practice when the pest has arrived in a new country without the enemies which keep it down in its original home. The method is then to seek out the parasites and predators which attack the pest in its country of origin and try and establish them in the new one.

With the expansion of commercial banana growing in the early part of the present century, damage due to the borer weevil took on a more serious aspect. In 1912, the Fiji Department of Agriculture sent F. P. Jepson to Java to investigate the natural enemies of *Cosmopolites*. He found a beetle *Plaesius javanus*, of the family Histeridae, to be the main enemy of the borer there, and succeeded in conveying 3,792 living specimens to Fiji where they were liberated in 1919. Five years later *Plaesius* was found to be established over a wide area of Fiji, which in 1936 began to be a source of supply for other countries.

An attempt to establish *Plaesius javanus* in New South Wales in 1915 was a failure. No great success was achieved in Jamaica in 1918 and 1919, but a further attempt with Fiji material in 1937 and 1938 appears to have been successful. In a number of Pacific Islands good results have been obtained.

Three consignments of *Plaesius javanus* were sent from Java to Uganda in 1934 and 1935. They did not travel well and the few survivors cannot be assumed to have retained their full vigour. However they were liberated on a small island in Lake Victoria where the bananas were heavily infested with borers. Visits were paid to the island in 1937 and again in 1945 but no living *Plaesius* were discovered, and the damage done by borers in the banana gardens is said to have increased.

A second natural enemy of the banana borer was discovered in Malaya in 1936. This is a beetle *Dactylosternum hydrophiloides*, of the family Hydrophilidae. It was introduced into Queensland in 1938 and two years later Veitch (1941) reported that it was increasing rapidly.

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OBSERVATIONS ON EUROPEAN POTATOES IN TANGANYIKA

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VARIETIES

The following varieties of potatoes were planted at Lushoto (latitude 5° S., altitude 4,400 ft. in the Western Usambara Range) between March and July, 1946, primarily for observations on resistance to Irish blight (*Phytophthora infestans*):—

1. 653d (22).
2. 833b (98).
3. 834c (29).
4. 835a (4).
5. 914b (52).
6. 931b (5).
7. 1253a (25).
8. 1256a (23).
9. 914a (91).
10. Kerr's Pink.
11. Skerry Blue.
12. Arran Chief.
13. Flourball.
14. Kinongo (Syn. Northern Star)
15. Kiraya.

The first eight varieties were supplied by the Scottish Society for Research in Plant Breeding, Corstorphine, and were received in Lushoto on 9th March, well sprouted (except 931b) and in excellent condition. There were six tubers of each variety and as they were of good size it was decided to cut the majority of them, which gave a total of 87 setts. The cut surfaces were allowed to heal and all except seven setts of 931b (unsprouted) were planted on 16th March. The seven setts of 931b took another three weeks to sprout and were not planted till 6th April.

The variety 914a (91) is also a Corstorphine product, received via the Senior Plant Pathologist, Kenya—three tubers in February, 1945, and 50 in January, 1946. Planting of this variety took place between 6th April and 12th July, the total number of setts planted being 226 (plus 22 chats weighing under half an ounce each). All the 50 tubers received in January were planted whole, and about one-third of the locally multiplied tubers were cut.

The remaining varieties are of long standing in East Africa and although they appear to have survived in Kenya they have almost disappeared from the Usambara area of Tanganyika, owing to Irish blight. Planting of these varieties took place between 16th March and 26th April.

CULTURAL TREATMENT

A dressing of kraal manure (almost pure cow dung) was given at the rate of 15 tons to the acre. The crop was planted in drills, spaced 2½ ft. apart with the setts placed 10 in. apart in the drills. A heavy watering was given to the varieties planted in March, as the soil was very dry at the time and overhead irrigation in the form of artificial rain was given as required. Although the early planted crop could have come through on the rainfall alone, the latest plantings could not have produced a full crop, and the only feasible way of comparing varieties which had received different amounts of rain was to ensure that *all* varieties had abundant moisture throughout their growth. The usual cultural operations of moulding, etc., were carried out.

RECORDING

Except in the case of the local varieties, careful records were maintained of each individual plant during growth and at harvesting, so that the progeny of diseased, unthrifty or unusually vigorous and high-yielding plants could be kept separate for subsequent planting. In this account it is only proposed to summarize the accumulated data regarding yield, disease, behaviour during growth and other characteristics of interest.

YIELD AND MATURITY

Table I below summarizes the yield and maturity data available; rainfall figures are omitted as they have little significance owing to irrigation having been practised. Planting dates have already been referred to and as these and the dates of harvest would unduly complicate the table they are omitted, and only the average period from planting to harvesting is given. The yield in tons per acre (although of little value from a statistician's standpoint) is included as providing a more comprehensive standard than yield per plant. The number of plants per acre lies between 19,300 and 23,200 (because of the varying size of the setts) and a round figure of 21,000 has been taken for the purpose of computing the yield per acre. "Chats" (at harvest) have been taken as tubers weighing roughly less than one ounce. A few setts failed to produce plants because of rotting, cutworm and grub damage, etc., and these have been excluded from the table.

Table I

Mean Yields of Varieties

Variety	Number of plants	Maturity	Yield per plant	Yield per acre	Best plant	Number of tubers per plant: Ware and Seed	Number of tubers per plant: Chats
		days	*lb. oz.*	*tons*	*lb. oz.*		
653d (22) ..	12	106	0 8	4·5	1 9	4·9	3·1
833b (98)	10	111	1 8	14·1	3 7	6·0	2·8
834c (29)	10	106	0 15	9·0	1 3	5·7	2·9
835a (4)	11	112	1 5	12·1	2 12	4·2	0·7
914b (52)	11	112	1 9	14·5	2 12	9·0	1·7
931b (5)	9	93	0 12	7·1	1 6	4·3	3·0
1253a (15)	11	96	0 9	5·1	1 10	3·7	1·8
1256a (23)	11	96	1 5	12·1	2 2	8·2	1·8
914a (91)	198	128	1 8	14·8	3 10	5·3	0·7
Mean of varieties ..	—	107	1 2	10·4	—	5·7	2·1
914a (91) Chats ..	22	128	0 15	9·0	1 12	3·4	0·3
Skerry Blue	59	102	0 10	5·7	1 12	4·5	2·1
Flourball	9	100	0 12	7·0	1 14	4·0	2·5
Others	Yields negligible and not fully recorded						

Table II shows the total amounts harvested from the Corstorphine varieties:—

Table II

Variety	Number of plants	Yield	Number of tubers Ware and Seed	Chats
		lb. oz.		
653d (22) ..	12	5 12	59	37
833b (98) ..	10	15 1	60	28
834c (29) ..	10	9 10	57	29
835a (4) ..	11	14 11	46	8
914b (52) ..	11	17 6	99	19
931b (5) ..	9	6 13	39	27
1253a (15) ..	11	6 0	41	20
1256a (23) ..	11	14 3	90	20
914a (91) ..	220	317 5	1,118	150

Misses caused by rotting of setts in the ground amounted to two out of twelve in the case of 834c and eighteen out of 238 in the case of 914a. There is some evidence that the planting of freshly cut tubers is accompanied by heavier losses than the planting of tubers which are given time to heal first. The following figures, representing losses through rotting in 238 setts of 914a, are of interest in this connexion:—

Whole tubers: four losses out of 140 = 2.9 per cent.

Cut and healed: six losses out of 77 = 7.8 per cent.

Freshly cut: eight losses out of 21 = 38.6 per cent.

There was no appreciable difference between the yields from cut and uncut tubers. In the case of 914a, 80 cut tubers averaged 1 lb. 8 oz. per plant, and 110 uncut tubers averaged 1 lb. 7¼ oz. As is normally the case, large setts gave a larger number of tubers than medium setts, but no appreciable increase in weight.

Notes on Varieties

Ignoring the two varieties 1253a and 1256a, which succumbed to blight, the Corstorphine varieties more or less complied with the descriptions given to them for earliness by the Plant Breeding Station. The differences were not, however, marked, excepting the case of 931b which definitely behaved as a First Early, and 914a which in some cases took as much as 140 days to mature.

Cooking qualities have not yet been tested, but from the point of view of yield and appearance I should place the varieties tested in the following order:—

(1) 914b (52).—By far the most attractive potato and, together with 914a, is likely to prove the finest cropper. It is superior to 914a in that the tubers are nearly all of medium size. The high number of tubers per plant is a great

asset in multiplication of the variety, as it obviates excessive cutting. From harvest to sprouting took 71 days, which with its maturity period of 112 days fits in exactly with the two planting seasons of the Usambaras.

(2) 914a (91).—Has many of the good points of the previous variety, but to a lesser degree. The tubers are inclined to be oversized and not so regular in shape. Sprouting took place in 61 days.

(3) 833b (98).—In the same yield class as the previous two varieties, but the tubers are too large, irregular and deep-eyed to be easily marketable. May prove very useful in areas where potatoes are grown mainly as a native food crop. From harvesting to sprouting took 67 days.

(4) 835a (4).—Has similar faults to the previous variety and did not yield so well. Sprouting took place in 74 days from harvest.

(5) 1256a (23).—This variety, had it not gone down with blight, would have been a very strong competitor for first place. In spite of the fact that it contracted the disease in less than two months from planting it tied for fourth place in the yield table. The appearance and size of the tubers are on a par with the best variety, 914b.

(6) 834c (29).—Below the average in yield and appears to suffer from some intrinsic weakness in the tuber, which will be referred to under the heading "disease".

(7) 931b (5).—A poor yielder and of very poor appearance with a wrinkled skin. This was the only variety which had not sprouted on arrival from Edinburgh and the crop which was lifted in June shows no signs of sprouting after 120 days, which is most unusual in this part of Tanganyika.

(8) 653d (22).—Gave the worst crop of all and is suspected of virus disease. One plant appeared to be healthy and gave a yield of 1 lb. 9 oz., and this has been kept separate for further trial.

(9) 1253a (15).—Made poor growth right from planting. It contracted blight and eventually all the tubers rotted in store. This was the only variety with a coloured skin.

Local varieties (all blight susceptible) have been omitted from the above list as comparison between blight-susceptible and blight-immune varieties would convey a wrong impression. As it happens, both Flourball and Skerry Blue were definitely better than the last two varieties in the list, but if an early attack of blight had occurred they would probably have missed this distinction. On the other hand, if there had been no blight at all they would quite likely have figured still further up the list. Flourball is an attractive pink-skinned variety and Skerry Blue a purple-skinned variety of very irregular shape and with very deep eyes.

FOLIAGE AND FLOWERS

The habit of a potato variety in a temperate climate bears no resemblance to the habit it adopts under conditions at Lushoto (4,400 feet), and probably in most other parts of the tropics. The varieties grown, while conforming to such standards as "erect", "spreading", etc., in the very early stages of growth, soon fell into the category "straggling". (There was one exception to this, 653d, which was short and erect throughout its growth, but this was almost certainly due to leaf roll.) This collapse of the haulm, which often takes place suddenly owing to a gust of wind or a shower of rain, results in a good deal of breakage, secondary rot of aerial portions of the plant and bad aeration, and in consequence must have quite an appreciable effect on yield. It seems, therefore, that strength and erectness of the stem is an important character in the selection of varieties for the tropics. 931b showed a very marked tendency to breakage of the leaf petiole even before the haulms fell over.

The only varieties which produced flowers were 834c, 914a, 914b and 1253a. 834c and 914b produced fertile seed from which a number of seedlings were raised.

DISEASES

Blight.—Excepting 1253a and 1256a, all the Corstorphine varieties remained completely free from Irish Blight. They were grown among susceptible varieties (Arran Chief, etc.) and were frequently rubbed with diseased leaves and had diseased material thrown on them at night. Blight did not make its appearance till nearly two months after planting and the order of destruction of the foliage was roughly as follows:—

Arran Chief, Kiraya, Kerrs Pink, 1253a, Kinongo, Flourball, 1256a, Skerry Blue.

Leaf Roll.—With the exception of one single plant this disease was very severe in the variety 653d. The affected plants were a light green colour and remained stunted throughout their growth. The single healthy plant gave a yield of 1 lb. 9 oz., while the diseased plants gave yields varying between 3 and 14 oz. Eight plants of 914a also showed strong symptons of leaf roll and four of these gave yields of only a few ounces.

"Virus".—An unidentified leaf disease was prevalent on 833b during the first two months of growth and was also present, to a lesser extent, in other varieties. At a distance the disease resembled blight, but on close inspection this resemblance vanished and one found grey, limp patches which later turned brown. Specimens were sent to the Senior Plant Pathologist, but no fungus could be found and he concluded that it might be a virus symptom. The disease, if it was in fact a disease, did not at any time become serious.

Early Blight (Alternaria solani).—This disease, of long standing in the Usambaras, was present on all varieties, but caused little, if any, damage. Normally, the disease makes its appearance fairly late in the season and only late-planted crops suffer to any appreciable extent.

Brown Rot (Xanthomonas solanacearum).—This disease (formerly known as "Ring Rot") was found in about twenty plants of the variety 914a. The disease was present in the short rains crop, so presumably it was carried over undetected in the tubers, as the land on which the potatoes were planted was definitely clean. There was no suspicion of wilt in the crop and it was only on cutting the tubers across at harvest that the disease was discovered. A tuber from every plant was cut across at harvest and those plants which were definitely diseased were destroyed. The progeny of suspect plants is being kept separate for planting in isolation and steps are being taken to surface-sterilize the tubers from healthy plants. This disease may prove to be our most difficult problem in potato work at Lushoto.

Tuber Rot.—An unaccountable soft rot affected the tubers of 1253a soon after harvest and in a few days all the tubers were a rotten mass. The writer was absent from the station at the time and on his return deterioration had gone too far to enable specimens to be submitted to the Plant Pathologist. An unidentified disease also attacked the tubers of 834c and caused a necrosis of the skin and immediately beneath. In some cases a secondary rot set in and destroyed the tuber, but in others the damage failed to penetrate further than just below the skin. In the tubers which failed to rot, premature sprouting occurred within three weeks of harvest; a few of these were planted and the resultant plants, now two and a half months old, are growing strongly and producing healthy tubers.

It now seems probable that these last two tuber conditions were caused, or at any rate accelerated by fumigation with carbon bisulphide. All tubers received a light fumigation after harvest to get rid of root mealy bug, and although none of the other varieties was damaged (even those treated in the same receptacle) it seems possible that the two varieties affected may possess some special intolerance to certain toxic substances. 834c was the only one of the 1946 importations in which rotting of setts after planting occurred.

INSECT PESTS

There was an outbreak of cutworm which threatened to do a great deal of damage but was fortunately brought under control by dusting with pyrethrum powder. Capsid bugs and Jassid were also present, but not to any alarming extent.

ACKNOWLEDGMENT

The Department is greatly indebted to Dr. Nattrass, the Senior Plant Pathologist in Kenya, for the patient and expeditious way in which he dealt with the numerous specimens and inquiries addressed to him in the absence on leave of Dr. Wallace, Plant Pathologist, Department of Agriculture, Tanganyika.

THE ROLE OF PASTURE DEVELOPMENT IN SOIL CONSERVATION, TANGANYIKA TERRITORY

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Soil erosion is a formidable obstruction to progress in the development of agriculture and live stock in this Territory. Over large areas the protective natural vegetation has been destroyed, and this has caused marked deterioration in the structure and water-retaining capacity of the soil, with consequent loss of fertility. In some areas native cultivators are moving down the slopes in pursuit of the retreating soil moisture; in others they are cultivating new ground further up the slopes and thereby increasing the run-off and accumulation of water in the valleys and swamps. By disturbing the balance of water-distribution in the hills and valleys, a great deal of damage is caused by flooding of fields, roads and railway lines. The remedy does not lie in the construction of more flood-embankments and larger bridges but in more effective control of the run-off from overgrazed pastures and from badly farmed agricultural land. New constructional work may be desirable in some places, but the excessive run-off can often be controlled very effectively and comparatively cheaply by maintaining a close-growing protective cover on the grazing areas and by adopting effective soil- and water-conservation measures on cultivated land.

Advancing economic standards and an increased demand for manufactured goods have resulted in a quickening of farming activities which has disturbed the rotation in shifting cultivation. In addition communities are increasing in size and require larger areas for cash crops and food. Both these factors have caused a reduction in the proportion of land under fallow, so that the period of rest is shortened and soil deterioration is more rapid. Pasture development is closely linked with improved methods of land utilization, and even in the closely settled areas of Tanganyika a good system of husbandry should do much to prevent any real land shortage. Although the ideals of soil conservation cannot be attained in a year or two, a start can be made by applying the elementary principles, such as the use of protective belts of grass along gullies, water courses, contour banks and contour-strips. These measures could be used as a protective framework until a co-ordinated policy for balanced soil utilization can be developed. Continuity of policy is essential, and a combined effort by both individuals and Government Departments is required. Most of the conservation measures which are briefly discussed here are not new but have already been applied successfully in other countries. It is not contended that any one of these would form the entire solution to this large problem, but if properly orientated and applied they cannot fail to counteract deterioration and to bring about measurable improvement.

The most difficult part of the work lies in persuading the farmer to accept the ideas and methods of good husbandry and soil conservation, and it is only the most straightforward and simple of these which stand any chance of success.

SOIL CONSERVATION MEASURES

Grass as a protection against run-off.

All types of water-courses, including gullies and their banks, should be permanently protected from cultivation, kept free from thicket, and wherever possible grass growth should be encouraged and maintained. The width of the protected margins depends upon local conditions, though a verge three yards wide on either side along the tops of gully banks could be used as a convenient working basis. Margins of about twenty yards in width should be excluded from cultivation on both sides of all big roads and railway lines and allowed to become covered with grass. Verges should also be left on both sides of district roads, tracks and paths.

Recent experiments at Mpwapwa have confirmed earlier work which showed that run-off is greatly reduced by a pasture sward. Over a period of about four months, with 17.85 in. of rain, run-off was reduced to one gallon for every 23.33 gallons of rain which fell on flat grass-covered land, compared with a loss of one gallon for every 5.46 gallons which fell on flat cultivated land planted to a crop of sorghum.

Contour banks, grass strips, and hedges.

Contour banking has received much attention in the past and it can be used very beneficially in conjunction with other measures. However, damage to fields in areas where contour banks are not properly constructed, and where neglect may occur, is a real danger. During heavy downpours the banks break and result in streams flowing down the middle of fields, causing surface wash and forming new gullies. The construction and the maintenance of contour banks require a great deal of labour and time, and on badly eroded or marginal land such work is uneconomic from the farmer's point of view. It should be regarded as a corrective measure only to be applied in special circumstances. It is essential that contour banks should be correctly aligned and excess water allowed to spill on to grass-covered drainage channels. Perennial grasses and useful legumes should be established along the contour banks and channels. The banks should not be cultivated and when first built should be protected with thorn branches where available.

At frequent intervals along the contour, strips should be left uncultivated and allowed to become covered with grass, as these form useful barriers to hold silt and to disperse the water before it reaches the water courses. A protective covering of thorn branches greatly facilitates grass growth, and the erection of thorn fences round fields and paddocks, as well as round the uncultivated strips, should be encouraged. Burning of branches on cleared fields should be prohibited or restricted, as these should be used to protect contour banks and other places where erosion is likely to take place. Live hedges of Manyara (*Euphorbia tirucalli*) should also be encouraged.

The respective widths of the uncultivated belts and the alternating belts of cultivation must of necessity vary with local conditions, soil types, degree of slope, rainfall and other factors. As a general rule uncultivated strips three yards wide alternating with belts of cultivation thirty yards wide may be found suitable. In addition to this, trash lines of grass and weeds should be made at more frequent intervals in the cultivated area to prevent erosion between the more permanent barriers. In areas where conditions of soil and weather are favourable suitable perennial plants such as bananas, sugar cane and elephant grass can be established along some of the uncultivated strips; the banana trash and other plant residues should be placed along these belts to ensure their continuity. In less favourable areas a close growth of perennial grass should be encouraged and protected. Very good results have been obtained from such a system of strip cropping carried out on a very extensive scale in native farming areas in the Teso District of the Eastern Province in Uganda.

Contour fallowing.

In many parts of the Territory it is customary to cultivate continuous belts of land. These often extend up from the river valleys over great distances on the hillsides, without any breaks or barriers to disperse the flow of water and are usually adjacent to fallow fields which also extend from the bottom of the slopes to the top, and which invariably become badly eroded by numerous cattle tracks and gullies.

If this customary method of cultivating and fallowing large belts of land up and down long steep slopes could be re-orientated into a system of contour-fallowing, the general system of contour stripping or banking would be strengthened and in addition it would form a practical foundation on which to build a system of ley-farming on organized rotational lines. The system successfully adopted in the Teso District of Uganda is a period of three years cultivation followed by three years rest, but the period of rotation would of course depend upon local conditions.

Tie-ridging.

Tie-ridging, which is described by Prentice in this Journal (Vol. 12, 1946), effectively prevents run-off and loss of soil moisture, and it also retains fertile soil particles which otherwise would be washed or blown away. Although heavy soils are not suitable for tie-ridging it is a measure for which there should be wide scope throughout the Territory. Prentice writes: "An acre under four-foot ridges has 3,630 running yards of drill, and the same number of basins if the ties are only a yard apart. With one-inch rain, each basin receives about six or seven gallons of water". This would amount to the conservation of about 25,000 gallons per acre. In practice run-off would be eliminated when fields are tie-ridged.

Control of burning.

It would be virtually impossible to forbid burning in all circumstances but considerable advances in this direction might be made, especially in densely settled areas. Cleared vegetation and crop residues should never be burnt unless it is imperative to do so because of disease or for other reasons. Plant residues break the force of running water, disperse the flow during downpours and allow a larger proportion of the rain to be absorbed and retained in the field.

Veld types and systems of management.

The carrying capacity of a grazing area can only be given as an arbitrary figure and it depends just as much on the farmer as it does on the animal or the pasture. Food supplies available at the height of the dry season are the limiting factor and not the extent of growth during the rains. Carrying-capacity figures should be based on a twelve month period at least, taking into consideration food supplies during the scarce seasons and lean years rather than on the highest production levels. Reserved grazing, hay, clover, ensilage and grain supplement are essential to bridge the unfavourable periods which occur frequently in this variable African climate. Grass strips and verges would not only aid to a considerable extent in dispersing flood water and in the holding up of silt but would form useful "fodder banks" and a network of grazing reserves to be used when their crop residues become available during the dry season.

Communal grazing reserves, controlled under systems of veld management, do much to relieve the situation during drought periods but cannot solve the problem entirely until the number of stock is controlled to suit local conditions. Pasture grasses are easily ousted by thicket growth in the competition for light and moisture, and this process is accelerated by uncontrolled grazing. In order to maintain a dense grass cover, it is essential that woody thicket should be cleared and proper grazing control methods applied. Goats feed mainly on woody and herbaceous plants, and in a well-balanced farming system they can assist in reducing woody growth. However, excessive clearing of pasture or veld is a mistake, and a sufficient number of trees should be left for shade.

In most areas it is most economical to encourage the development and protection of natural pasture and fodder plants rather than to try to establish extensive areas of exotic species. The solution of the pasture problem therefore, to a large extent, lies in the proper utilization of indigenous herbage, and to this end we should concentrate on systems of planned rotational grazing, veld management and the conservation of all available fodder.

Cattle tracks.

In mountainous country cattle-tracks cause much erosion. The situation could, however, be alleviated to a considerable extent if a combined system of contour fallowing and water course protection were to be adopted. Water concentrating in cattle tracks should be dispersed at convenient points. Paths and drain furrows demarcating individual fields, should be grass covered to prevent serious erosion.

SUMMARY

The serious nature of soil erosion problems in Tanganyika Territory is emphasized. Soil-conservation measures which can be fitted into different farming systems are discussed. These measures are to a large extent based on protection for the soil in the form of entire or partial grass cover.

The importance of making as much use as possible of local material and indigenous plants is stressed.

The measures which are advocated are cheap and many of them involve little or no effort. They are based upon sound and proved soil conservation and farming practices, and have already been found to be effective in the field.

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"The farmers should remember that the specialist officer is forced by his job to know 'more and more about less and less'; it is unreasonable to take a young plant pathologist or soil chemist to look at the bull and to expect him to criticize it as if he were an experienced live stock officer. He may turn out to be a farmer's son and a shrewd judge of an animal, but that does not necessarily make him a better plant pathologist or chemist, and that after all is what he is paid to be".—Prof. J. A. Scott Watson, C.B.E., L.L.D. (1946), in introducing the National Agricultural Advisory Service.—Agriculture, LIII.7.283.

NOTES ON CHICKPEA AND ITS CULTIVATION IN THE LAKE PROVINCE, TANGANYIKA

By **C. G. Clegg, Agricultural Officer, Tanganyika Territory**

(*Received for publication 22nd April, 1947*)

Chickpea (*Cicer arietinum* L.) is of very ancient cultivation and believed to be a native of the Levant. Its origin has been traced to *C. pinnatifidum* Jaub & Spach, which is found in Asia Minor, Syria and Palestine. It is an important cold season crop in India, where it is commonly grown in rotation with rice following on after that crop has been reaped. It was probably introduced into East Africa by the Indians, who cultivated it on a garden scale.

Chickpea is recorded as having been grown since 1932 for sale to Indians in the Mwanza and Kwimba districts. It was not until 1943 that this crop became important as an economic one, when in 1942 it was realized that chickpea was potentially a very valuable crop to the native grower, for in Kwimba 350 tons were grown and sold at an average price of £10 per ton.

The fact that imports from India were stopped during the war gave an added stimulus to its production. In 1943 an extensive drive was commenced, encouraged by the Agricultural Department. It was estimated that there were some 7,000 growers in Mwanza and 3,000 in Shinyanga districts. Since that date the crop has advanced in popularity with the cultivator and provides him with handsome returns. It is a crop well suited to parts of the Lake Province where the land is heavy. A few natives have also taken to eating it, although only small quantities are consumed in this way.

In the Lake Province, in dry years, chickpea is of greater value than groundnuts and comparable in value to the paddy crop. In dry years groundnuts and paddy fare badly and a fair amount of chickpea is planted on land prepared for paddy but not planted because of drought. In years when the rainfall extends into May and is heavy, chickpea suffers from waterlogging and blight.

TABLE OF PRODUCTION AND VALUES (In short Tons and £'s.)

DISTRICT	1942		1943		1944		1945		1946	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
Mwanza	—	—	414	5,800	624	8,500	670	10,720	473	6,638
Kwimba	350	3,500	403	5,700	431	6,008	378	6,134	271	4,107
Shinyanga ..	—	—	—	—	73	985	48	726	47	1,511

Chickpea is planted usually in May, though a little earlier is preferable if the rains are light. It needs little rain either for establishing or subsequent growth and actually suffers with a rainfall which for other crops would be reasonable. It is not troubled by drought and thus is well suited as a late-planted crop under Lake Province conditions.

The best soils are those that are heavy but not waterlogged, such as the black cotton soils which are to be found extensively in the area. Chickpea is grown to a lesser extent on black loams and sandy soils, but yields on light land are very poor. In a bad rice year when storms have not been enough to flood the paddy dams, chickpea can be planted on the land which has been prepared for paddy.

The fields should be well cultivated. On the heavy soils planting is on the flat, while on lighter soils ridging is more usual. The crop is sometimes interplanted with young cassava. Seed is sown one or two per hole, the holes one foot apart. Ten pounds of seed is normally adequate per acre. A good stand is essential for high yields.

Harvesting is done in June and July when the leaves change from green to brown. The stem is cut below ground level with a hoe and the whole plant is removed and spread out to dry near the homestead for a few days. Seed is flailed out on an earthen threshing floor. The average yield for the area can only be guessed at and is probably below 350 lb. per acre. Yields are considerably lower for crops on light land. It is, however, possible to obtain up to 1,700 lb. per acre on the heaviest soils with a good stand.

In 1943 the mean yield of the local variety grown on heavy black soil at the Mwabagole Rice Station, Ukiriguru, Mwanza district, was 1,700 lb. per acre, valued at £12. The land had been prepared for paddy, but could not be planted due to drought. This high yield compared with the low local native yield stimulated interest in this crop.

In 1944 the Mwabagole yields were 1,220 lb. per acre—over eight acres—but on black soils at the Ukiriguru station the mean yield was only 500 lb. per acre.

In 1945, at Mwabagole, also on land which had been prepared for paddy but could not be planted owing to drought, the mean yields of six strains of chickpea were:—

Local:	1,471 lb. per acre.
IP 53:	1,260 lb. per acre.
IP 58:	1,040 lb. per acre.
IP 17:	1,030 lb. per acre.
F 8:	910 lb. per acre.
IP 25:	810 lb. per acre.

The local strain is earlier and has a spreading habit, whereas the Indian varieties are later and more upright. No blight was recorded in the above trials.

In 1943 "Chickpea Blight", a serious disease of chickpea, was recorded in Kwimba. It was the first recorded occurrence of its kind in East Africa. Later, in 1943, it was found in other districts. In the Kwimba area it was estimated that 50 per cent of the crop was lost due to this disease.

The disease is endemic in Bulgaria, where 20–50 per cent losses in crop are reported. In the Punjab, in some seasons, there is a total loss. It is caused by the fungus *Ascochyto rabiee* (Pass.) Lab. It is most prevalent—in the Lake Province—where the rainfall in the growing season exceeds about six inches, but when the rainfall is light apparently less loss occurs. The affected parts of the plant appear as if scorched. If stems are attacked at or near the ground, as often happens, the plant is completely girdled and dies. Wind helps in spreading the disease by blowing infected material from place to place. The susceptibility of plants is stated to increase with age and to be the greatest at the flowering and fruiting stage, so that wet weather at this time would greatly increase its spread.

The practical methods of control suggested are: (*a*) the removal and burning (or burial) of all diseased plant material at the end of the season; (*b*) the rotation of at least two years with crops other than chickpea; (*c*) the use of healthy seed. The disease may be carried in the seed, but the main source of infection seems to be seed externally contaminated with the fungus spores, and yet, disinfection with either chemicals or hot water has not been found to be very effective; (*d*) spraying with Bordeaux mixture or lime sulphur three or four times during the season; this has been found to be quite effective, though in the present instance the latter method would not be practicable for the African grower.

The question of planting dates for controlling these losses was considered, and in the Shinyanga district the first week in April was suggested as being the earliest planting date. Different soils might require different planting dates. A campaign to uproot and burn all diseased plants met with good success and rotation with other crops has been advised.

It was found in the Punjab that a type F 8 was highly resistant to blight, though not to wilt disease which occurred as a result of drought and other unfavourable conditions. In view of this, seed of F 8 was obtained from Pusa for trial and comparison with the local strains. Seed of types IP 17, 25, 53 and 58 had previously been received. The origin of local Mwanza types is not known, though at least two are recognizable by differences in the seed coat.

Chickpea could be an important crop in the economy of the Lake Province if prices remain sufficiently attractive. At present it is popular with the people and prices are high (around 15 cents per pound). It is planted late in the year after other crops have been planted and before the main harvesting starts.

In drought years it can be planted on land prepared for paddy planting. In most years in the Lake Province the rains stop fairly sharply around mid-May. Good stands are essential for good yields and it is here that at present the peasant cultivator fails. A considerable amount of chickpea—probably induced by the present high prices—is planted on soils too light and poor for reasonable yields.

At present there is a drive for increased cassava planting, the need is greater therefore for such a crop as chickpea to improve the balance of the African's food, and there should be an increased consumption by the peasant himself.

Thanks are due to Dr. G. B. Wallace, Mr. D. Sturdy and Mr. M. Lunan, of the Department of Agriculture, Tanganyika, and Mr. J. Peat, Empire Cotton Growing Corporation, for information used in this article.

NOTES ON ANIMAL DISEASES*

Compiled by the Department of Veterinary Services, Kenya Colony

IV—RINDERPEST

Rinderpest is an acute contagious virus disease of ruminants and swine, characterized by diarrhoea, nasal and lachrymal discharge and by ulceration of the mucous membrane of the mouth.

Etiology.—Rinderpest is caused by an ultra-visible and filtrable virus which becomes attached to the white cells of the blood and blood-forming organs.

Symptoms.—After an incubation period of from two to nine days the temperature rises sharply to 104° F. or more. The muzzle appears dry and the coat staring. The appetite is reduced, and after one or two days a little discharge is noticed at the eyes and nose. The eye becomes very susceptible to light and the mouth very congested. The temperature remains elevated for three days to a week, after which it falls to normal or below normal. At this time coughing may be noticed, diarrhoea is always present, and an examination of the mouth will show pitted elevations of the lower gum, the dental pad, the inner aspect of the angles of the mouth, and the sides and lower surface of the tongue. By this time the animal has usually lost condition, the eyes are sunken and the flanks hollow. Grinding of the teeth and other symptoms of abdominal pain are evident, and diarrhoea becomes more and more marked. Dysentery is frequently observed, and the animal becomes very weak and unable to rise. Death usually occurs ten to twenty days after infection. Breakdowns to redwater and less frequently to coccidiosis may occur; pregnant animals that recover from the disease usually abort during the third week after infection.

Post-mortem Lesions.—In natural cases of the disease in adult animals the post-mortem lesions are usually characteristic. The mouth, pharynx, larynx, and, in the female, the vagina are markedly inflamed and show patches upon which the epithelium has become lost or changed into a cheesy deposit. Although considerable areas may be raw, examination of adjacent areas less severely affected shows that the lesions begin as numerous pinhead-sized ulcers. Larger areas are formed by the confluence of numbers of such ulcers.

The fourth stomach is usually intensely inflamed and several shallow irregular-shaped ulcers with hæmorrhagic margins are almost constantly present. On the folds in the anterior portion the ulcers are usually very narrow and elongated. Nearer the junction with the intestines (the pylorus) the ulcers are more round or oval in shape, and traces of yellowish-grey necrotic mucous membrane may still be adhering. Diffuse congestion and sometimes free hæmorrhage is present in the small intestine. In the large intestine the cæcum shows typically a network of broad bands of congestion and longitudinal lines of hæmorrhages are constantly seen in the rectum. Diffuse patches of congestion and hæmorrhage may be present throughout the large intestine.

The liver and spleen are usually somewhat swollen and engorged with blood. The kidneys are congested, particularly the medullary (inner) portion of the pyramids. The mucous membrane of the bladder often shows small hæmorrhages, and of course when a breakdown to redwater has occurred the urine is deep red in colour.

Usually the lungs show emphysema—distension of lobules and septa with air—so that small bubbles are seen on the surface. Some congestion or secondary pneumonia may also be present. The heart shows small black hæmorrhages, under the membranes lining both the outside of this organ and the inside of the cavities.

The typical mouth lesions of rinderpest occur in one other disease of cattle only—malignant catarrh. In Kenya diarrhoea and intestinal lesions are rarely seen in the latter disease, while the very marked increase in size in the lymphatic glands in malignant catarrh makes differential diagnosis easy. Isolated cases of rinderpest in calves or in partially immune animals may be somewhat atypical in that the characteristic mouth lesions may be lacking. Usually, however, rinderpest is one of the easiest diseases to recognize.

Animals Susceptible.—All ruminants and pigs are susceptible to rinderpest, but the degree of susceptibility varies. Among domesticated animals, cattle and buffalo are highly susceptible, mortality in uncontrolled outbreaks of the disease often surpassing 90 per cent. In East Africa sheep and goats are relatively resistant to strains occurring naturally: although these animals may be infected by the inoculation of virulent material, apart from a temperature reaction they show little evidence of infection. In French West Africa, however, a large breed of goats occurs which reacts severely to inoculation. Pigs on infection behave similarly to sheep and goats. Camels are slightly more susceptible. Among wild species, buffalo, eland, kudu, and wart-hog appear to be the most susceptible. Mortality in these species is heavy, and they are of great importance in spreading the disease from farm to farm and from district to district. Giraffe, bush-buck and forest-hog are only slightly less susceptible, but although other species of buck may contract the disease mortality in them is unusual.

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* A revised edition of an article published in this Journal, Vol. 5 (July, 1939).—*Editor.*

Although herds of buffalo and other game are of great importance in the spread of rinderpest in East Africa, it is the considered opinion of those who have studied the question that game do not harbour rinderpest for long periods. Rinderpest spreads rapidly in buffalo herds, so that after a comparatively short time all the susceptible animals have either died or recovered to become immune.

Transmission.—Rinderpest is a contagious disease. The virus is present in all the discharges of sick animals, and healthy cattle contract infection through eating or drinking contaminated material. The virus is a relatively delicate virus, being rapidly destroyed outside the animal body by physical and chemical agents. Blood at room temperature loses its infectivity in a few days when kept under the most favourable conditions, and materials splashed with blood become harmless in three days even when stored near freezing point.

The virus does not resist the action of O.C.G. preservative, and for confirmation of diagnosis blood should be collected in sterile citrate solution and despatched to the Laboratory with as little delay as possible.

Treatment.—There is no specific drug of value in the treatment of rinderpest. Hyperimmune serum in doses of 250 to 500 c.c. may be used for cattle that have been exposed to infection, but it is very doubtful if the inoculation of hyperimmune serum can modify the course of the disease when it is given after symptoms other than a rise in temperature have appeared.

Bleeding a few hundred cubic centimetres from the jugular vein appears to be beneficial when the temperature is high.

Preventive Inoculation.— Rinderpest is usually combated by prophylactic inoculations. Several methods are available, each of which has its uses.

The oldest method in use to-day is the "serum alone" method. Serum alone gives immunity for two to three weeks only, but protection is afforded as soon as the serum is injected. Serum alone is only employed therefore in an emergency. For cattle of average susceptibility the dose is 15 c.c. per 220 lb. live weight, but for more susceptible animals the dose should be increased to 20 c.c. per 220 lb. or more.

For the protection of high grade and pure-bred dairy cattle inactivated vaccine is employed. A course of vaccine will usually confer protection for from one to four years. Highly susceptible cattle appear to gain a more durable immunity than cattle of low susceptibility, and the response to vaccine is better in fully adult animals than in yearlings.

It has been found that once an animal has received a full course of three doses, immunity may be reinforced by a single annual inoculation of vaccine. When using vaccine therefore the recommended procedure is to give every animal a full course of three inoculations of 10 c.c. at weekly intervals once it is over twelve months old. In subsequent years the animals previously treated with a full course receive a single 10 c.c. dose, whilst the yearlings that have come on since the last inoculation receive a full course of three doses.

When calves are inoculated by any of the methods in use to-day a proportion, which may exceed 50 per cent, fails to develop a durable immunity. Calves may be given a single dose of vaccine when rinderpest is in the vicinity of the farm, but otherwise can be left untreated.

The other methods of immunization necessitate the use of live virus, which in Kenya may only be employed by the staff of the Veterinary Department. These methods differ from those already described in that in adult cattle they confer a life-long immunity.

The first of these methods to be developed was the double inoculation method, which was first introduced into Kenya by Montgomery in 1910. In this method, serum is inoculated on one side of the animal and virus on the other. The severity of the reaction is controlled by the serum, and the animal develops a mild attack of the disease, as a result of which adults acquire a life-long immunity. In calves, however, the resultant immunity may not be permanent.

The disadvantages of the method arise from the difficulty in accurately balancing the dose of serum and from the fact that, if reactions are severe, infection may spread into game. Severe reactions may occur in animals in poor condition or in animals exposed to bad climatic conditions. Animals premunized to redwater and anaplasmosis may relapse and pregnant female stock often abort. The mortality as a rule does not exceed 2 per cent.

Shortly after the introduction of inactivated vaccine in Kenya, the possibility of converting the temporary vaccine immunity into a more permanent form was explored, and the vaccine-virus method was eventually elaborated. A single dose of 15 c.c. of vaccine was given, followed 13 to 15 days later by a large dose of spleen virus. Resulting reaction was usually milder than that following double inoculation and in some cases was imperceptible. The immunity produced appeared to depend on whether a satisfactory reaction was induced by the virus. When a good reaction occurred, the immunity was probably as durable as that following double inoculation, but a variable percentage of animals did not react and became susceptible again when the vaccine immunity had waned.

In view of the difficulty and expense involved in preparing large quantities of serum and vaccine, search for a cheap, efficient immunizing agent has been in progress for many years. The only hope of eradicating rinderpest from territories like the East African territories, populated as they are largely by backward peoples owning herds of low-valued cattle, lies in the wholesale immunization of stock with a cheap product conferring a durable immunity.

Experiments conducted by Edwards in India showed that when rinderpest virus was passed many times through goats its virulence for cattle decreased. As a result of these experiments, goat virus was introduced in India for the field immunization of the relatively resistant plains cattle. This virus was imported into Kenya in 1937, but was found to be too virulent for use on local cattle. Passaging of the stock Kabete virus had been started in 1936. No evidence of attenuation was noticed until the 85th passage, after which passage the virus became progressively less virulent, and early in 1939, after 270 passages, it proved suitable for use as a field immunizing agent provided that the cattle were in good condition, that grazing was good and that there was no exposure to inclement weather during the reaction period.

Since 1939 many millions of cattle have been inoculated with Kabete attenuated goat virus. In addition to being used locally virus has been sent to West Africa, Egypt and Ceylon. The strain of virus has now been passaged over 700 times in goats and appears to have become fixed in virulence for cattle. Certainly attenuation has not been marked over the last 400 transfers.

Like all methods conferring an active immunity, goat virus must produce a reaction to achieve a result. As in double inoculation, therefore, a small mortality is almost unavoidable. With ranched Zebu cattle, however, under good conditions, mortality is negligible and this method of inoculation has become popular is most native reserves in Kenya. The ease with which large quantities of virus can be prepared at low cost has enabled inoculations to be done on a very large scale and, as a result, more than 90 per cent of the cattle in most of the reserves south of the Northern Frontier District have been immunized. The effect of these inoculations on the frequency of outbreaks of rinderpest, both in the reserves and in the settled areas, has been very satisfactory; but as the wild virus can be spread by game, the time has not yet arrived when farmers can safely discontinue the protection of their cattle.

Just as the reaction to bovine virus in the double inoculation method was controlled by the use of serum, so it has been found possible to reduce the severity of Kabete attenuated goat virus reactions by giving a small dose of serum simultaneously. There has, therefore, developed another method, Kabete attenuated goat virus plus serum, which has replaced the vaccine-virus method for European-owned ranch cattle. This method is also being used on grade herds; but owners of valuable cattle are still advised to protect their stock with inactivated vaccine. The disadvantage of the Kabete attenuated goat virus plus serum method are firstly, the risk of mortality, which must always be present, and secondly, the fact that the reaction to the attenuated virus is easily blocked by serum, so that a percentage of cattle may receive no protection from the inoculation. In order to reduce this percentage, a further inoculation of Kabete attenuated goat virus without serum is given two–three weeks after the original inoculation, when the protection afforded by the serum has worn off.

During the war years, by serial passage in developing hen eggs, a new attenuated virus was developed by a Joint United States-Canadian Commission working on an island in the St. Lawrence River. Virus attenuated in this way can be used for the inoculation of grade cattle without fear of causing mortality. Unfortunately, however, about 20–25 per cent of susceptible cattle fail to react and do not gain any immunity from the inoculation. It is hoped, however, that it will be possible to overcome this serious disadvantage and produce a cheap, safe and efficient immunizing agent that will give durable immunity to high-grade stock.

REVIEW

"The Forage Resources of Latin America: Peru": By Hugo W. Alberts. Bulletin 37 of the Imperial Bureau of Pastures and Forage Crops, Aberystwyth, Great Britain. January, 1947.*

General.—The author gives a brief introduction of conditions at the time when the Spaniards arrived in Peru and describes the three major geographic regions, namely, the Coastal Region, the Sierra and the Oriente or Montana.

The rainfall in the coastal area only lasts for a few months of the year, while for the remainder it is dry. The altitude varies from sea level to 1,000 metres. The Sierra region lies between 2,000 metres to over 4,500 metres and consists of fields under crops, pasture and range areas. The Oriente or eastern part consists mainly of tropical forest with savannah grazing lands in cleared or periodically burnt areas. There are cultivated pastures along the river bottom lands, but these are relatively few. The altitude varies from less than 200 metres to 2,000 metres.

Out of a total of 1,250,000 square kilometres, cultivated pastures and lands planted to hay, soiling and silage crops comprise approximately 1.20 per cent, and native grasslands or range lands probably more than 16 per cent. The balance consists of crops, forest and waste lands.

Coastal Region.—In the coastal area, most of the forage lands are irrigated. The cultivated pastures are planted to alfalfa (*Medicago sativa*), para grass (*Panicum purpurascens*), Guinea grass (*Panicum maximum*), Rhodes grass (*Chloris gayana*) and ryegrass. When planted on irrigated land such pastures generally must compete with other crops of great economic value. The natural pasture herbage species vary according to topography and other local conditions of climate. The pastures of the dry coastal plains consist mainly of annual species.

Grazing animals in the coastal region include goats, dairy cattle, beef cattle, sheep, horses, donkeys and hogs. Sheep are relatively few on account of the high temperatures and because some of the land can be more economically utilized for cash crops. Supplementary feeds in the different regions vary and consist of green fodder, hay, grain or algarroba pods (*Prosopis chilensis*). "A number of dairies near the larger centres of population, having as many as 500 to 1,300 head of cattle, frequently have no pasture for the animals. All forage is cut and fed green after running it through an ensilage cutter. Some dairy animals . . . are pastured on alfalfa and para grass . . . The crop lands are pastured following the removal of the crops."

Sierra Region.—It is mentioned that in the highland areas of the Sierra region a large proportion of the grasses are short and it is interesting to note that Kikuyu grass (*Pennisetum clandestinum*) and white clover (*Trifolium repens*) also occur; "Kikuyu grass is a comparative newcomer . . . It was introduced in trial plots at the Chuquibambilla Experiment Station in 1923, escaped from cultivation, and is now found in many areas along the Southern Railway". Land owners call it a noxious weed and say that whereas formerly stands of alfalfa lasted five to six years, it is now ousted by the Kikuyu grass in two to three years. Some farmers have found that the fields can be cleared by using a special harrow. *Melinis minutiflora* (Molasses grass) is mentioned as one of the principal rocky mountain slope grasses, but it is said that despite reports to the contrary it does not repel mosquitoes, ticks or snakes.

In the Sierra region, sheep, alpacas, llamas, beef cattle, dairy cattle, donkeys, horses and pigs are grazed. Sheep constitute the largest number of animals. The range lands do not receive much attention and large flocks of sheep and other live stock are herded wherever there is pasture available.

The Oriente.—"Only limited areas in the Oriente are utilized for forage, since the land is covered by tropical rain forest vegetation." Low-growing fodder legumes are comparatively rare as they get suppressed by tall-growing clump-forming species like *Panicum maximum* and *Hyparrhenia rufa*, while cleared areas are rapidly invaded by stoloniferous species like *Pennisetum clandestinum* and *Paspalum conjugatum*. *Paspalum notatum*, which is mentioned as a dependable pasture forage in the eastern foothill region of the Andes Mountains, occurs on low mountain tops subject to fogs.

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* Price Sh. 2/6, Central Sales Branch, Imperial Agricultural Bureaux, Penglais, Aberystwyth, Great Britain.

The forest vegetation is expensive to clear and it has not in general been found profitable to clear land for pasture only. Cattle and hogs are kept. The principal pasture supplements are elephant grass (*Pennisetum purpureum*) and other species.

Various poisonous plants occur, but generally these are not eaten by live stock unless the grasses become extremely short. *Nicotiana glauca* is mentioned as one of the dangerous species.

A note on palatability is interesting and the author states that it varies not only with the different species of herbage, but also with different types of live stock. He reports, for example, that Swiss cattle can thrive on *Stipa ichu* while Holsteins do not. Furthermore, plants such as alfalfa are always relished by all kinds of live stock, while certain species, for example *Melinis minutiflora*, are relished only after the animals have become accustomed to them.

In certain respects there seems to be a large degree of similarity with East African conditions of climate with variation of pastures and carrying capacity depending upon altitude and rainfall.

A considerable number of the fodder plants and other species mentioned also occur in East Africa.

H. J. v. R.

PRE-BAITING VERMIN

Pre-baiting for one or more days is a well-known system of rat control; but usually only small amounts of pre-bait are laid before the same food is given with poison added. An extension of pre-baiting has been used in Hawaii and also by the Bureau of Animal Population at Oxford to obtain accurate field measurements of relative population density of brown rats (Chitty, *Nature*, vol. 150, p. 59, 1942). Wheat, which has been found the most suitable bait, is put out day after day at the pre-baiting point decided upon. There may be a lag of as much as twelve days before the rats start to feed on the bait: then more and more wheat is taken by the rats each day until the quantity disappearing becomes fairly constant. Thereafter, the fluctuation in the amount they take daily is surprisingly small—less than 15 per cent. By this means the relative size of localized rat colonies can be gauged and the individual feeding experiments now in progress will enable the data of absolute amount of bait eaten to be used to give the absolute, and not merely the relative, number of rats in the colony. It is thought that the method should be applicable to other populations that consist of only one species of small mammal. Meanwhile the immediate practical interest of the work lies in the fact that when pre-baiting has been continued until the amount taken by the rats ceases to increase, then if the bait is poisoned it gets the whole colony.

For pre-baiting, use 50 per cent freshly roasted and ground groundnuts, and 50 per cent maize meal (posho). The poison should be 20–25 per cent barium carbonate and 75–80 per cent of the groundnut-maize meal mixture.

SOME EXPERIMENTS IN NATIVE AGRICULTURE IN THE ELGEYO-MARAKWET DISTRICT OF KENYA

By J. B. Carson, M.A., District Commissioner, Elgeyo-Marakwet, Kenya

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The district of the Elgeyo and Marakwet tribes consists of some 1,100 square miles of hilly broken country roughly 1°N. and 35.5°E. It may conveniently be divided into three zones: the high country (7,500–9,000 ft.), the escarpment, much of which is sheer cliff (5,000–6,500 ft.), and the valley (3,500–4,000 ft.). The altitudes quoted are approximate.

THE PROBLEM

In general the natives live on the escarpment, herd their cattle in the high country and keep their goats in the valley. The problem of the district may be summarized as that of inducing the population to leave the escarpment, and to encourage them both to cultivate and live in either of the other two zones. This cannot be accomplished without some approved system of agriculture, grazing control and soil conservation, so that the people may be moved without the fear of handing over fresh land for destruction. In this district there is still time for action before the increasing pressure of live stock and population exhausts the fertility of the land and causes serious soil erosion, as has happened in the Machakos district of Kenya.

CLIMATE AND VEGETATION

The high country forms the main watershed between the Nzoia system and the Kerio, and contains a considerable area of valuable gazetted Native Forest Reserve, with cedar, podo and olive as the chief economic species. Outside the Forest Reserve there is much natural regeneration of Kikuyu grass, *Pennisetum clandestinum*. Through overgrazing, however, this has largely given way to a coarse wire grass, *Pennisetum schimperii*. In the main grazing areas, Lelan and Cherangani, the stony hills carry a thin grass cover, mostly red oat grass, *Themeda triandra*, which is also replaced by wire grass when overgrazed.

The escarpment contains a few ledges where some soil has been deposited, but in the main it is too rocky and steep for tillage, and it contains some deplorable examples of hillside cultivation, principally of finger millet, *Eleusine coracana*. The valley, on the other hand, seems to offer possibilities, even although it is at present little cultivated, and is largely unfit for human habitation on account of the heavy incidence of malaria mosquitoes, drought and tsetse fly.

GENERAL CONSTRUCTIVE MEASURES

As regards the high country, the first requirements are reduction of stock, improvement of herds, and possibly the introduction of sheep, such as Romney or Merino. Use of manure, rotation of crops, and protection of slopes by contour grass ridges are also necessary. Constant propaganda is directed to this end and supervision is exercised by native agricultural instructors who have been taught the use of the line level. Work has also been started on the eradication of weeds in pasture, in particular sodom apple, *Solanum campylacanthum*, a *Vernonia*, and a peculiar prevalent perennial, locally known as *chelelmet*, which is closely related to *Erlangea tomentosa*.

Ledge cultivation on the escarpment requires careful soil conservation measures and the use of compost and silage pits; but so steep is most of it that the ideal—at present impracticable—would be to abandon it by moving the population elsewhere.

The valley provides a difficult problem, but an interesting one, and it does seem possible that it could be converted from bush and scrub into a large food producing area. There are five good rivers, in addition to the Kerio River which forms the administrative boundary with the Baringo district. The introduction of crop rotations might be feasible after large scale clearing, tsetse fly elimination, and the control and improvement of existing water supplies.

CROP TRIALS AND SOIL CONSERVATION MEASURES

Although there has been no agricultural officer in this district, the efforts of the Administration have for some years been directed towards finding out what types of crops are best suited to the various zones. From 1942-45, through the efforts of the District Commissioner, great strides were made, resulting in an increase of trial plots up to 27. These plots are still superintended by the District Commissioner, assisted by an African Senior Agricultural Instructor, and there is a native Agricultural Instructor in charge of each plot. As a result of field trials, suitable crops were planted in the many communal farms which were sited in all parts of the district to to save the population from the periodic famines to which they have always been subject in the past.

These trial plots are used not only for experiments with new crops, but also to provide sources of seed for free distribution; at the same time they serve to demonstrate proper methods of cultivation. The average size of a plot is about two acres.

THE HIGH COUNTRY

In the high country a variety of crops have proved successful.

Legumes.—Lima beans (white): Being perennial they also give the soil a good rest. Peas: Marrowfat, King, Alderman and Field all do well.

Cereals.—Barley: Prior and Maltworthy do well, but they have little appeal since threshing is hard work; Naked or Hull-less are likely to be more effective. This year, oats and sunflowers were successfully grown for seed and might eventually be handed out for trials as "pioneer crops" with a view to improving poor pastures. *Chenopodium Quinoa*: This is not a cereal but would count as such in rotation. At high altitudes it ripens early and is drought-resistant. In the event of a failure of ordinary cereals it might be possible to effect a late quick planting. It resembles a wild chenopodium, and the Marakwet natives will eat it in times of scarcity. It is also a good poultry food and is a useful green manure. Maize needs no encouragement, since it is more extensively planted than before, even at high altitudes where it takes nearly a year to mature. The customary local cereal, finger millet, is of better food value but is less frequently planted nowadays. Maize and finger millet are chiefly used for making native beer.

Root Crops.—For some time English potatoes have been extensively and profitably grown as a cash crop. Present prices provide encouragement for this greedy crop, which is inferior in some respects to sweet potatoes, the latter having the advantage that they remain longer in the ground without rotting, make a good stock feed and bind the soil. The best variety appears to be a Kikuyu one with forked leaf, red roots and tubers, known in that vernacular as *Gikunga.*

Grasses for Contour Banks.—A tall tussocky grass, known in Kikuyu as *Kigutu,* is successfully used in most location plots. It has been propagated by seed and root division and it has the advantage of being a useful thatching grass. The other successful contour bank grass which grows well in all the zones is *Paspalum notatum.* As a ley grass, *Bromus marginatus* seems to be most promising and may be the key to developing family holdings.

Hedges.—Mauritius thorn, *Caesalpina sepiaria* is slow but grows well, but it requires careful weeding in its early stages. E. L. Bradford (this Journal Vol. 12, p. 83) mentions that, in the Bukura district of Kenya (altitude 4,850 ft.), Mauritius thorn must be kept well trimmed to prevent it getting out of hand, but he adds the warning that constant trimming causes it to die out after about seven years. These remarks seem to apply equally for altitudes up to 8,500 ft.

THE ESCARPMENT LEDGES

On the escarpment ledges at 6,500 ft. most crops seem to do well and large trees such as *Cordia holstii* flourish.

Cereals.—Maize: Both yellow and white varieties do well, preferably interplanted with beans.

Legumes.—Bonavist bean or njahi, *Dolichos lablab* is an excellent soil restorer, gives good soil cover for a year or more without replanting, and is also a good food. Other beans successfully tried in small quantities include Black Velvet No. 719, Lima Red, and Lima Wachugga No. 907. Both appear inferior to white Lima beans which do quite well at 6,500 feet, but in general are more suited to the high country. In addition to these, Canadian Wonder, Rose Coco, small white Boston and Victory all do well on the escarpment ledge.

Root Crops.—Sweet potato (*Gikunga* variety) does very well.

Grasses.—Experimental plantings made here this year with Molasses grass *Melinis minutiflora* and *Phalaris tuberosa,* Syn. *P. bulbosa* are promising. A variety of grass established on the escarpment for several years is Rhodes grass *Chloris gayana,* which is very similar in appearance to a local wild form.

The Valley

In the valley the object has been to find drought-resistant, quick-ripening crops, popular with the inhabitants.

Cereals.—Most successful of the sorghums is the short-stemmed, quick-ripening variety known as "Dobbs", which grows without irrigation and yields a heavy crop within three months. The other variety, which is known as Kano, is red and is similar to Dobbs. But the yield is lighter and the seeds more vulnerable to weevil. The seeds in any case are best mixed with wood ash and kept in a gourd since they are generally prone to attack by weevils.

Of finger millet, a Kisii variety from South Kavirondo, Kenya, has proved the most successful in the valley because it is both quick-ripening and drought-resistant. It is now widely distributed. Although it gives lower yields per acre than maize or sorghum, it has a higher nutritive value, being rich in calcium. It is also more tolerant of shallow and rocky soils, of which there is much in the valley.

Bulrush millet appears to be potentially valuable as a quick-ripening drought-resistant crop. It was tried out quite successfully in a small acreage and deserves further trials, but it is unlikely to be popular since it is very prone to attack by birds.

Legumes.—Cowpea is the most successful legume here. It is drought-resistant, easy to harvest and to cook, and ripens in two to three months. There are two kinds: the purple flowered with mottled seed, and the white flowered with white seed. The former seems the better for general use.

Groundnuts are an excellent crop, given good weather or helped by a little irrigation, and they are the most popular legume in the lowlands of Marakwet. The most satisfactory planting space seems to be 1 ft. by 1 ft.; planted further apart they tend to suffer from Rosette disease. Three kinds have been tried: Coast, Nyanza and Bambare No. 808. Whilst the second of these has been most commonly planted, the Coast and Bambare varieties deserve further trials. It is worthy of comment that in August last the Groundnut Commission from Great Britain saw Coast groundnuts in a plot in this area and expressed a very favourable opinion on them. Large scale production is likely to be the key to the future development of the valley in providing valuable food both for consumption and for export as a cash crop.

Greengram does well under the conditions in the valley, but it is unlikely to become popular since it is laborious to harvest. It would probably be of value as a cash crop and it could be worked in a crop rotation with cereals.

Pigeon peas might seem to be an ideal crop for the low country, but on trial in most places they have been unsuccessful, due to heavy infestation by grubs on the bushes, damage by weevil when stored, and the fact that they seldom survive the dry weather, when they are killed by white ants.

Other Crops.—Cassava is rather disappointing in the valley since it will grow only under irrigation, without which it is killed by white ants in the dry season. Sweet potatoes suffer in the same way in that they seldom survive the dry season without irrigation.

Grasses.—*Paspalum notatum* thrives as a contour grass. Alego Rhodes grass has done well where planted experimentally as a ley grass. It appears to be identical with a grass common in parts of the valley to which the Marakwet give the name *Chepengo.*

Fruit.—This seems a promising line in the valley where irrigation channels can be led. Bananas, cashew nuts, mangoes, pineapples, custard apples, pawpaw and citrus all do well.

There are considerable potentialities for citrus fruit growing under irrigation; if marketed on a co-operative basis this might well prove a valuable cash crop. Fruit canning is another possibility, as also are the cultivation of pawpaws and production of papain.

CONCLUSION

Everything done in this district during the past few years has had the objective of laying foundations for a big expansion of work when staff and funds become available. The main lines of work have been experiments with new crops, seed-bulking and propaganda to introduce a crop rotation with special emphasis on legumes.

Large scale attack on a few easily defined objectives seems to have proved more profitable than diffused efforts on a large number of more detailed schemes. It is easier to popularize something of which the good points are obvious than something which only yields obscure or long term benefits; for example, *Kigutu* grass is easier to introduce for general planting as a wash stop than *Paspalum notatum* because of the former's additional value as a thatching grass. The people are naturally lazy; therefore a crop that is easy to look after and harvest can be more easily popularized than a difficult one. They are conservative; therefore a better variety of a well-known crop, such as "Dobbs" sorghum, has a stronger appeal than something strange. Native likes and dislikes need to be studied; they cannot always be followed, but when practicable should be considered, for it is easier to get the people to plant something they like, or at least tolerate, than something they heartily detest.

PLANT INJECTIONS FOR DIAGNOSTIC AND CURATIVE PURPOSES

By Peter S. Cooper, N.D.A., C.D.A., Department of Agriculture, Uganda

Despite the great advances made in plant mineral deficiency work during this century and the corresponding advances in methods of diagnosis, both by chemical analysis or injections, little has been written concerning the use of medical hypodermic syringes for injection work designed to aid both the diagnosis and cure of mineral deficiencies. During the fifteenth century that almost universal genius—Leonardo Da Vinci is recorded as having been the first user of a syringe for injection purposes. In these experiments, some of the first ever to be made on plant injection, Da Vinci described how he bored a hole into a tree, filled the hole with a liquid squirted in by a syringe, and finally plugged the hole with wood. No further reference to injections of plants by syringes is made until early in the 1870's when Erhart tried to inject plants with a hypodermic syringe for the purpose of following the course of the injected liquid by the damage caused to its tissue. To do this he inserted the needle into the surface layers of soft plant tissue and, pressing the piston as he withdrew the needle, filled the hole so formed with the liquid. This liquid, about 0.02 c.c. to 0.05 c.c. in volume contained 0.00125 grammes of dissolved salts.

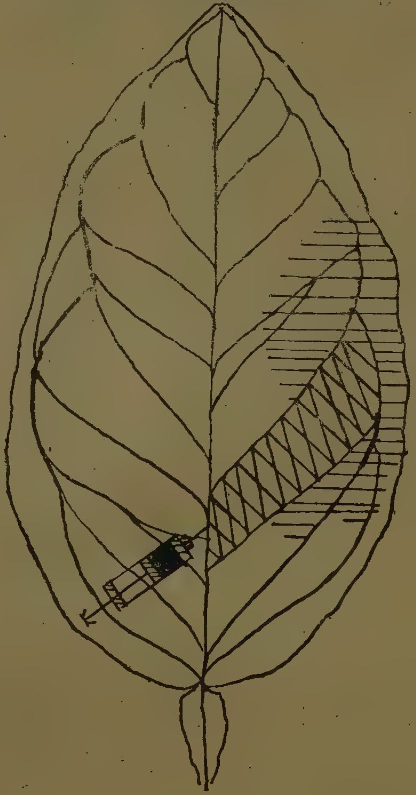
In both Da Vinci's and Erhart's method the syringe is used as a means of putting a liquid into a previously prepared hole, whether it be by a gimlet in Da Vinci's method or the needle of the syringe itself as in Erhart's method. Once the liquid was in the hole it was left to become absorbed by the plant and in neither case was the syringe used with the intention of forcing the liquid under pressure through the plant tissue. Strictly speaking, therefore, these two types of experiments cannot be termed injections in the correct etymological sense of the word. In this present paper the term injection will be used only where it implies the forcing of a liquid under pressure through plant tissue. Where it is allowed to become absorbed through tissue as in the two experiments already described then the term indirect injection will be used.

ADVANTAGES AND DISADVANTAGES OF USING HYPODERMIC SYRINGE FOR PLANT INJECTION

There are naturally many limitations to the method of using a hypodermic syringe for plant injections, the chief of which is that the plant, or part of a plant, to be injected must have tissues soft enough to allow the entry of a needle without filling the needle cavity, and secondly that the tissues injected should be sufficiently weak to allow the passage of a liquid under pressure through them, yet strong enough to withstand the pressures used. A further consideration is the necessity to take specimen plants or parts of plants (e.g. leaves) of a size sufficiently large to allow the needle point to enter, firstly, without causing death or serious damage to the injected part and, secondly, ensuring that the pointed needle tip is completely embedded in the plant tissue.

Against these limitations, however, which, as will be shown later, are not serious in practice, must be put many advantages, of which the first must be rapidity of both methods and results, a very important consideration in any form of diagnostic or curative work. The use of a syringe in diagnostic work, though requiring practice, can be easily and quickly carried out in many plants once the necessary skill has been obtained. The rapidity of diagnosis depends upon certain factors of which the age and type of plant, deficiency involved, and probably the atmospheric temperature immediately surrounding the plant, must be mentioned; of these, however, the age of plant and type of deficiency involved are the most important. Generally speaking the younger the plant the quicker is the reaction to an injection. In considering the rapidity of reaction caused by various nutrients, nitrogen naturally produces the most striking results, an alteration in leaf colour being perceived in less than 12 hours after the injection. Calcium has shown an effect on coffee seedlings three days after injection, and, though iron has produced a noticeable difference on iron-deficient greenhouse tomatoes within 36 hours, three to four days is a more usual time. With citrus, however, seven to eight days is generally needed before any perceptible signs of change can be noted. These and other factors relating to the deficiencies and reactions of the various nutrients will be discussed more fully under the section referring to nutrient solutions. Lastly, in considering the advantages and disadvantages of hypodermic injection methods, the fact that the actual injection is carried out in a few moments and is entirely unaffected by any climatic agencies is

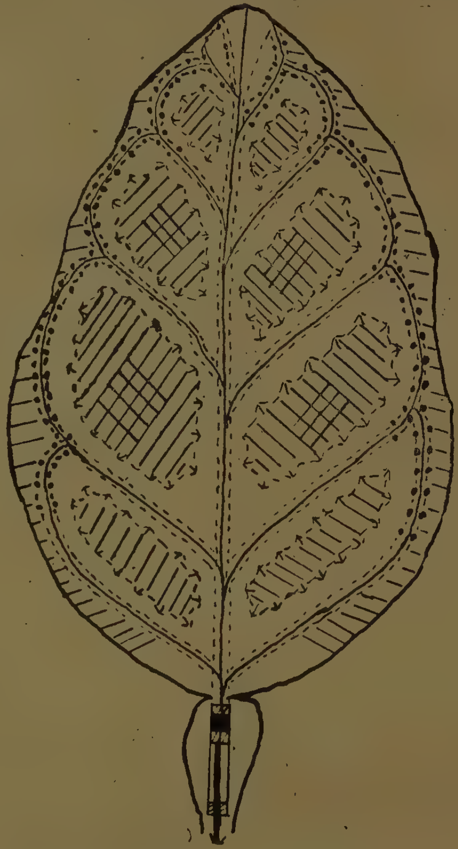
FIG. 1.—RESULT OF LEAF TISSUE INJECTION OF A GRAPE FRUIT LEAF.



Spread after one minute - - - - - XXXX

Spread after fifteen minutes - - ≡

FIG. 2.—RESULT OF VEINAL INJECTION ON A GRAPE FRUIT LEAF



Immediate spread denoted by — — — — — — - - - -

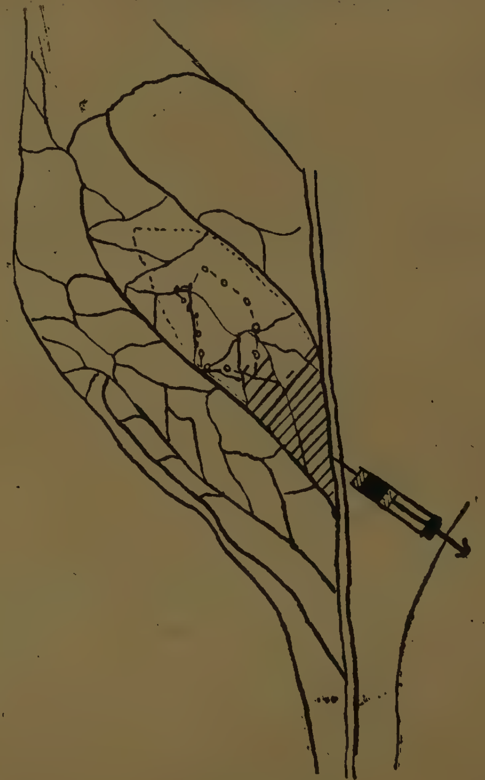
Spread within five minutes denoted by — — — -.-.-

Spread within fifteen minutes denoted by direction of arrows to non-shaded areas.

pread within twenty minutes denoted by - - - - - - - /////

reas heavily permeated after 1½ hours denoted by ▦

FIG. 3.—RESULT OF LEAF TISSUE INJECTION OF A TOBACCO LEAF



Immediate spread denoted by - - - - - //////

Spread within two hours denoted by -•-•-•

Spread within six hours denoted by - - •-•-•-

important. In methods of indirect injection involving the absorption of a liquid either by the plant member itself, or by the agency of a wick, the time needed is generally from seven to twelve hours. During this time, especially in the equatorial part of the tropics, the effects of the sun's rays or the frequent occurrence of tropical storms, may greatly upset the procedure of the injection, either by evaporating the solutions or dislodging the apparatus.

CONSTRUCTION OF SYRINGE

In considering the type of syringe to be used for injections three main points should be borne in mind:—

Strength of syringe; resistance to back flow at relatively high pressures (back flow implying the passage of a liquid past the piston); type of needle.

The strength of the syringe is important when strength implies the resistance of the glass cylinder to the internal pressures attained. In many types of unsupported glass cylinder syringes continued use results in breaking of the cylinder through the strains set up, and this type of syringe cannot be expected to last for any length of time. The resistance to back flow is necessary if controlled injections are to be obtained or, in fact, any form of injection, for the trouble is cumulative and the syringe is soon useless; very slight back flow can at times be advantageous by alleviating high cylinder pressures which may be caused by blockage of the needle. In cases where back flow takes place the needle should be inspected and, if it is clear, the piston should be repacked, though this is rarely satisfactory and it is generally better to select syringes which are not troubled by back flow. In the discussion that follows on the types of syringes that have been used it will be shown that the most efficient syringe from all aspects of injection work rarely, if ever, shows back flow. The question as to the length and size of needle greatly affects the injection results because on the size of needle rests the amount of mechanical damage inflicted as well as the distribution of the injected liquid. The question of mechanical damage is the one of greatest importance, and this is determined more by the width of the needle than the length. The length is of more importance in determining the distribution of the injected liquid. In width, a needle should not be greater than 1/50th of an inch. Sizes greater than this cause unnecessary damage to the tissues without any advantages and except in exceptional cases smaller sized needles show no advantage over 1/50th in. The exceptional cases referred to are mainly cereal seedling plants and young grasses as well as very small leaves such as Mandarin (Tangerine). These difficulties can generally be overcome, however with practice and for all general purposes a needle of 1/50th in. diameter should be sufficient. In the case of stem injections for whole plants it is necessary to reach the vascular ring in dicotyledonous plants and between the endodermis and central pith of monocotyledons, and consequently the length of needle is to an extent dependent upon the age and size of the plant to be injected. For most general purposes a working length of ¼ in. should be sufficient (working length = length of needle from tip to syringe).

LENGTH OF NEEDLE FOR VARIOUS CROPS

Length up to ⅛ in.—Young cereals and grasses; mandarin leaves; groundnuts.

Length ⅛ in. to ¼ in.—Leaves of apple, orange, lime, lemon, grapefruit, tomato, coffee, cotton (and seedlings). Mango, avocado pear; young tobacco (seedlings and leaves), brassica, mangel, swede, etc.; pineapple, mature cereals and some grasses (e.g. *Dactylis glomerata, Pennisetum purpureum,* etc.); English potato (haulms), sweet potato, beans.

Length ¼ in. to ½ in.—Mature tobacco, leaves and plant; mature brassica.

Length ½ in. to 1 in.—Sunflower.

This division, however, is purely arbitrary in so far as that most plants will give satisfactory results from leaf injections with ¼ in. length of needle and only in the case of stem injection on mature plants such as tobacco is a working length over ¼ in. desirable.

TYPES OF SYRINGES

Two types of syringes have been used in the experiments to be described. One, a simple 1 c.c. glass cylinder syringe, and the other a 1 c.c. intradermal syringe. Both can be successfully used for plant injections but the intradermal type has a far wider range of use than the glass cylinder syringe. Reference has already been made to the necessity of ensuring that backflow of a liquid does not occur past the piston and this is less likely to occur in the intradermal syringe, where a rubber piston is used, than in the ordinary glass cylinder syringe, where a metal piston is used. In addition to this, however, the intradermal syringe has many other advantages over the glass cylinder syringe. It is stronger and more

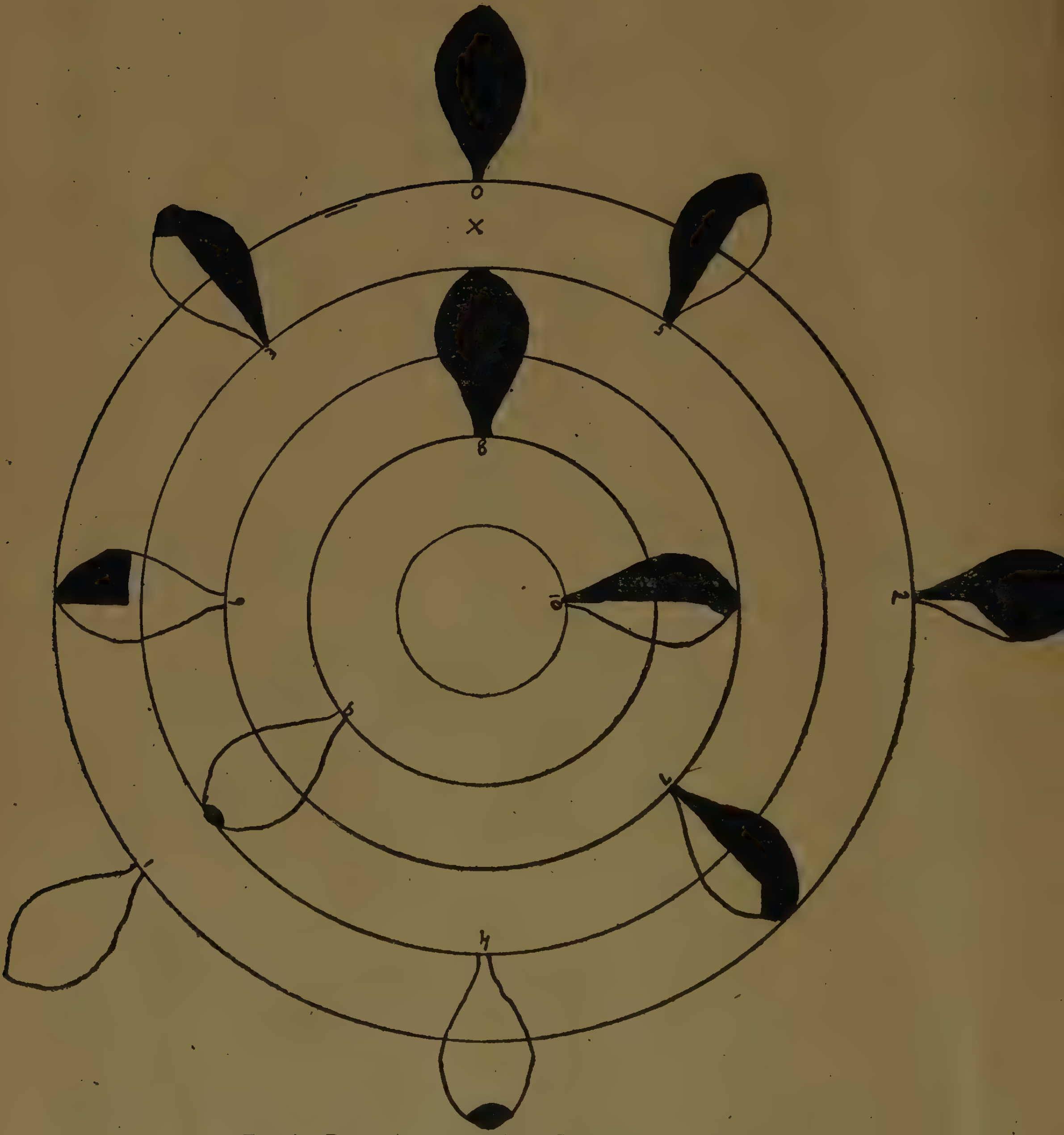


FIG. 4.—PHYLLOTAXIS AND STEM INJECTION OF TOBACCO

x designates point of injection

Permeated areas represented black

durable, and has graduation scales on both the cylinder casing and plunger rod on which is also a controlled adjusting nut, and, by means of which, absolute control is attained over the quantity injected. These additional facilities are not available on the more simple glass cylinder type of syringe and preference should therefore be given to the intradermal syringe.

EQUIPMENT REQUIRED

As the injections are carried out in the field the equipment must be easily transported. In most countries the distance over which equipment must be carried to the field is small, but in certain parts of the tropics distances to and from fields of operations are considerable and can be reached only on foot. Under these circumstances the following equipment appears the most economical and desirable.

(*a*) Three supported glass cylinder syringes (intradermal type). A minimum of three syringes is required if repeated washing on changing of liquids is to be eliminated. These, together with tubes containing spare needles and any incidental requirements such as scalpels, scissors, razors, etc., can all be carried in a roll up pouch.

(*b*) Liquid solutions. These are best carried in small tubes containing 1 to 2 c.c. of solution which can conveniently be packed either in small vest pocket cases or larger ones each containing about 24 tubes.

(*c*) Notebooks and string are always necessary, the latter being useful for denoting plants that have been treated; a combination of knots being used for the various liquid solutions used.

METHODS OF INJECTION

The method of injection depends largely on the type of plant used, but a few general principles apply to most cases. Firstly there are two distinct types of direct injection, one involving leaf injections and the other stem injections, whilst under certain circumstances root injections can be used, though these are of minor importance in diagnostic work. Of these types, leaf injection is the most widely used and produces the most successful results both from rapidity of diagnosis and also because it allows comparisons to be made between injected and uninjected leaves of the same plant, and even between interveinal areas on one leaf. There are two different methods of leaf injection, one involving the whole leaf area, termed the veinal method, and the other involving only a small area of the leaf, termed the leaf tissue method. These two methods of injection are carried out as follows; always in the back of the leaf.

The Veinal Method.—The needle is inserted in a slanting direction from the petiole to the midrib and at their junction, with the tip of the needle fully embedded in the tissue of the midrib. The opening of the needle should be in a straight line with the direction of the midrib. The piston should be depressed slowly so that only a light, steady pressure is maintained, in order to avoid excessive leakage around the injection point. Following this method of injection all major veins are immediately permeated with the injected liquid and within 15 minutes all minor veins are seen to be permeated as well. Should the needle be placed slightly to one side of the base of the midrib then the side on which it is placed will receive a greater degree of permeation than the other side; the nearer the needle point is to one side the less will be the permeation on the other side. In certain leaves (e.g. citrus), a small amount of liquid may break through the midrib at the point of injection. In leaves with larger midribs (e.g. tobacco), this is unlikely to occur, unless excessive quantities of solutions are injected. The rate and area of distribution are dependent not only upon the position of the needle during the injection but also by the quantity injected and the size of leaf. In small leaves 1/10th c.c. to 1/20th c.c. may be sufficient to permeate all veins but in large and mature leaves up to ⅓ c.c. may be required.

The Leaf Tissue Method.—In this method the needle is placed diagonally across the midrib so that the tip is close to the junction of the midrib and leaf tissue. With the needle injected from the left hand side of the midrib to the right hand side, with the point of the needle turned upwards, the liquid is forced through the veins and leaf tissue on the right hand side of the leaf opposite the needle point. If the point of the needle is turned down, when finally at rest in the injection position, the injected liquid is mainly concentrated on the side from which the needle has entered and only a small quantity will enter the opposite side. This applies especially to leaves with reticulate venation. The best position for this type of injection is about one-third the way up the midrib from the petiole, where the midrib is thick enough to allow penetration of the needle. Once the needle is inserted, pressure should be applied slowly as for the veinal method. Excessive pressure results in breakage of the tissue and leakage backwards along the injection hole. The area of distribution is dependent upon the quantity injected and the size of leaf, and generally speaking 1/10th to ¼ c.c. is sufficient. On no account should the whole leaf be permeated, as this will cause premature leaf fall before diagnostic symptoms are visible.

In deciding which of these two types of leaf injection to use the chief considerations are the temperature surrounding the leaf, and the size and type of leaf injected. Although the tissue method appears to be quite successful under most conditions, the leaf veinal method appears to be of greater use under lower air temperatures where the rate of transpiration is low. This type of injection can be used for most types of reticulate and parallel veined leaves. In warm climates and under glasshouse conditions, where the rate of transpiration is greater, this veinal method is rarely successful, and the leaf tissue method is generally used since the liquid remains for a greater length of time within the injected area. The type and size of leaf determining which method should be used will be discussed later under the section devoted to individual plants.

Stem Injections.—Stem injections find their greatest use in members of the grass family and with plants where jointed nodes occur. In these cases injection through a node at the base of the stem will produce permeation of all major veins above the injection point. The degree of permeation will depend upon the diameter of the stem, the distance to which the needle is injected, and the amount of liquid injected. In most instances, however, the leaves immediately above the injection point receive the greatest permeation whilst the leaves furthest from the side of injection receive less. Apart from members of the grass family, however, many other plants, with stems sufficiently soft to allow penetration of the needle, can be injected by means of this method. Such plants include most annuals, and some perennials in the seedling state (e.g. coffee). The area covered by the injection is determined mainly by the phyllotaxis of the plant. Those leaves immediately above the injection point receive the greatest degree of permeation whilst those subtended at a greater angle from the injection point receive progressively less. Where stem injections are precluded because of the structure of the stem, root injections may be used instead. This applies mainly to monocotyledons, especially maize, where the lack of jointed nodes and the presence of adventitious roots makes this possible.

Application of Injection Methods for Individual Plants

Having discussed the various methods of injections that can be used with syringes attention can now be paid to the adaptation of these methods to individual plant types. A description of the typical results obtained from such injection will be given later.

Citrus.—All species of citrus with the exception of the tangerine have leaves well adapted to leaf injection, especially by the leaf tissue method. In carrying out leaf tissue injection a leaf should never be fully permeated as this will result in premature leaf-fall. There is, anyway, no need fully to permeate a leaf with injected solutions, since it is only necessary to inject a portion of one interveinal area in order to obtain a comparative effect. The results of these leaf tissue injections are revealed by a semi-circular ring of improved colouring around the injection point in the interveinal area injected whilst the interveinal areas on either side remain untouched. (*See* Fig. I).

Coffee.—This plant is well adapted to both leaf injections in the adult state and stem injections in the seedling state. The most usual type of leaf injection is a combination of the leaf tissue and leaf veinal method. This is done by inserting the needle, as for the leaf tissue method, diagonally across the midrib till it adjoins the leaf tissue. Injected solutions will permeate the tissue immediately in front of the needle point but also there will occur a widespread permeation of all veins above the injection point and to a lesser extent below. In view of this, except where an interveinal area shows a very definite alteration in leaf colour, the whole leaf should be taken for interpreting the diagnosis, and comparisons made between that leaf and its neighbours, and not between interveinal areas on the same leaf. When the seedlings are too small or soft in the seedling stage to make leaf injections practicable, stem injections can be used. The needle is inserted at right angles into the stem and a gentle pressure maintained on the syringe. The resulting permeation from this type of injection is shown below.

No. of leaf above injection point.	*Fraction of leaf above permeated.*
0	Whole.
1	None.
2	Slightly more than half of left side.
3	Slightly more than half of right side.
4	Slightly less than half of left side.
5	Slightly less than half of right side.
6	None.
7	Whole.

Tobacco.—The tobacco plant lends itself admirably to both the leaf and stem injection methods. For leaf injection the leaf tissue method is the most suitable, the needle being inserted diagonally across the midrib to touch the leaf tissue on the opposite side and midway between two of the larger secondary veins. Pressure should be applied gradually when permeation of the interveinal area will result, the degree of permeation being dependent upon the quantity of liquid injected. For the most conclusive diagnostic results only sufficient solution should be injected to cover half the interveinal area, when none of the solution will cross over the two secondary veins bordering the interveinal area injected. Stem injections can be used for both seedlings and the distribution of an injected dye by this method is illustrated in diagram 4 where the plant has been drawn on a phyllotaxis plan. The phyllotaxis of tobacco is three-eighths. In the particular case shown in diagram 4, 0.70 c.c. of 1 per cent acid fuschin dye was injected 2 in. below leaf 0 and slightly to the left of it; 2½ in. below leaf 5, and 0.9 in. above the first rootlets. The injection took place at 6.35 p.m. The rate and degree of distribution was as follows:—

6.40 p.m.—Left side and tip of leaf 0 permeated in main veins.

6.45 p.m.—Dye discernible in left side and upper half of right side in main veins of leaf 5. Discernible in all veins of leaf 0.

6.50 p.m.—Dye discernible in left side of leaf 8.

7.00 p.m.—Leaf 0 becoming darker on left side and more fully permeated on right side. Slight permeation on right side of leaf 3, more distinct in leaf 5. No advance in leaf 8. Dye slightly discernible in left side of leaf 13 (not shown on diagram).

7.35 p.m.—One hour after the injection the following observations were made and on which diagram 4 is based:—

Leaf 0.—Coloured in all main veins on both sides of the leaf with all minor veins on left side and upper half of right side also permeated.

Leaf 1.—Untouched by dye.

Leaf 2.—Slightly coloured in all main veins and secondaries with the exception of the basal half on right side.

Leaf 3.—Very faintly coloured on right side and tip of left side.

Leaf 4.—Dye discernible at leaf tip only.

Leaf 5.—Colour well dispersed in all major and minor veins on left side and tip of right side.

Leaf 6.—Very faint coloration in three major veins three-quarters way up leaf on right side.

Leaf 7.—Faintly discernible on left side and tip of right side.

Leaf 8.—Dye clearly discernible, especially in right side in all main veins and secondaries.

Leaf 9.—Dye barely visible except at tip.

Leaf 10.—Visible in left side in main veins and secondaries and also tip of right side.

(The remaining leaves are not shown in diagram 4).

Leaf 11.—Very faintly discernible at tip of both left side and right side.

Leaf 12.—Ditto.

Leaf 13.—Well dispersed, though faintly, in all main and secondary veins especially on left side.

Leaves 14 to 17.—Dye very faintly discernible at tip of midrib.

Leaf 18.—Dye faintly discernible in main veins on left side.

Leaves 19 to 24.—No sign of any dye.

Twelve hours after the injection the dye had faded from all leaves, probably through the formation of its leuco-compounds, with the exception of leaf 0, on which interveinal permeation was still discernible, except on the basal portion of right side on leaf 5 on which very faint interveinal colouring on left side and tip of right side was discernible, as was also the case with leaf 8.

Tomato and Potato.—The English varieties of tomato under temperate conditions are suited to both leaf and stem injection methods, though the wild tomato seen growing to profusion in parts of the tropics is not so adaptable to leaf injections. Both the leaf veinal and leaf tissue method can be used on single leaves of the cultivated tomato, though the leaf veinal is generally the most useful method of the two. In stem injections a single branch should be used as the area to be treated, and the injection should be made at least midway between the stem and the branch tip so as to prevent back-flow of the injected solution down the stem. In this method of stem injection the solution will enter all leaflets above the injection. Deviation of the injection point to either side of the midway line will cause an excess of solution to enter the leaflets on the side adjoining that to which the injection was made.

English potatoes can be injected in the same manner as tomatoes, and the resulting distribution is very much the same. One point, however, that must be borne in mind in stem injections of both tomatoes and potatoes is the succulent nature of the stem when young, as this causes rapid bursting of the stem tissue immediately above the injection point and consequently injections must be made so that pressure is applied very slowly and gradually.

Cassava.—The cassava plant is adaptable to leaf tissue injection, petiole injection and also to injections made into the young branches. For the diagnosis of mineral deficiencies, however, the leaf tissue method is to be recommended as the most useful. Care must be taken to ensure that the injection is made at least one-third of the distance up the leaflet from the junction of the petiole else reabsorption may take place into the other leaflets. The petiole injection is carried out at the junction of the petiole and leaf when it is desired to treat the whole leaf area. Stem or branch injections can be made, preferably when the member injected is young. In carrying out this injection, however, care must be exercised, since the high resistance of the internal core or pith to the injected solution causes its rejection along the injection hole unless the needle is left in position for a few minutes after the completion of the injection, so allowing the solution to overcome the resistance of the pith and leave the immediate vicinity of the injection point.

Apple.—The apple leaf can be injected by either the leaf veinal or leaf tissue method, though the former is more generally successful. Great care has to be taken in the leaf tissue method in order to ensure that the needle is passed right across the midrib and is exactly in position adjoining the leaf tissue itself; unless it is far enough across the midrib, permeation into the leaf tissue will not take place. Once tissue permeation has been obtained, however, a further difficulty arises in that large quantities of the injected solution exudes from the leaf tissue, and though this does not damage the leaf it nevertheless reduces the efficiency of the injection. As a result of these two difficulties in leaf tissue injections it is generally quicker and more efficient to use the leaf veinal method.

Peach.—Owing to the general narrowness of the midrib in peach leaves, leaf tissue injections are often difficult to carry out and generally require considerable experience and skill in this type of injection, and consequently leaf veinal injections are more practicable.

Pineapple.—Injections for pineapple are carried out successfully by inserting the needle into the tissue of the leaf at an angle of 35°–40° to the leaf and one-third of the way up the leaf. The injected solution moves mainly up the leaf with little or no lateral movement. Downward movement is slight and with the lack of any lateral movement good comparative effects are produced between injected and uninjected areas on the same leaf.

Brassica.—All brassica leaves can be injected by either the leaf veinal or leaf tissue method. Stem injections in young plants can also be used, but since tissue injections can nearly always be used there is little need to resort to stem methods.

Groundnuts.—Injection of groundnuts is best carried out by means of petiole injection so that a whole series, generally of four leaves, is treated with one injection and the remainder of the plant left for comparative effects. Solutions travel through groundnuts very slowly and it is therefore advisable to make the injection as close to the leaf as possible, and in this case considerable skill is required if controlled injections are to be obtained. Injections can be made through the jointed node at the base of the petiole but the subsequent spread of solution is very slow, and, in addition, some re-allocation takes place.

Cotton.—The cotton plant can be injected by means of the stem injection method whilst in the young state, or by the leaf veinal or leaf tissue methods in the more mature state of growth, and although the leaf tissue method requires more skill than either the leaf veinal or stem method it is the most successful.

Avocado Pear.—Leaf tissue injections are the most adaptable and can be easily and quickly carried out.

Monocotyledonous Plants.—Injections of monocotyledonous plants generally involves using the whole plant as the injection unit. The injections are performed either through the node, when the needle is put in at right angles to the node; through the stem, in plants with solid internodes; or through the adventitious roots, as and when they occur above ground level. Injection through the node results in permeation of all the leaves immediately above the injection point. Stem injection on plants with solid internodes (e.g. maize), are not nearly as efficient as either root or node injections, as the subsequent spread of injected solutions is very variable and further work is needed before recommendations as to its use can be made. Adventitious root injections can be successfully carried out on maize plants, the needle being inserted into the root, close to its junction with the stem. The resulting distribution of solutions injected by this method occurs, in maize plants, in the upper third of the plant.

STRENGTH OF CHEMICAL SOLUTIONS

The strength of solutions used is dependent upon a number of factors amongst which can be included these six main points: Climate; age of plant; type of plant; point of injection; mobility of chemical used; and degree of efficiency.

As regards climate, the results of experiments during the hot dry season in tropical countries point to the fact that solutions weaker than normal should be used. Experiments conducted with solutions of ferrous sulphate at a normal strength of 0.1 per cent show that weaker solutions should be used and 0.05 per cent is preferable. In using 0.1 per cent of ferrous sulphate during the dry season unduly large necrotic areas occur in some plants, notably citrus. Solutions of 0.5 per cent magnesium sulphate tend to produce marginal leaf curl during the dry season which is not found in the wet season, and again a weaker solution should be used. These findings are substantiated by the results of the application of solid indirect injection methods during the dry season, when the application of a normal dose of ferrous sulphate causes severe longitudinal splitting of the trunk both above and below the injection point, as well as a blackening of the stem for a distance of four to five inches, with a width of three to four inches. In addition, all those leaves above the injection point, and all those which it was intended to treat, show premature leaf fall, and the wood generally takes on an appearance of death. Recovery, which occasionally takes place during the wetter months, is slow and incomplete and no fruit is borne in the succeeding season. It would appear therefore that in tropical countries during the dry season the strength of solutions, especially iron and magnesium, should be reduced to at least half the normal strength used. It is insufficient to reduce the quantity of solution injected without reducing the strength. Old and mature plants are capable of utilizing, with relatively little damage, more concentrated solutions than younger plants, this being especially noticeable in annuals.

The type of plant determining the concentration of a solution is, to an extent, bound up with the effects of climate, for mesophytic plants can utilize stronger solutions than xerophytic.

The point of injection is closely bound up with the mobility of plant nutrients when considering the concentration of solutions to be used. Thus the mobility of a nutrient such as nitrogen is such that, when a deficiency occurs, the symptoms are more pronounced on the older leaves, the available nitrogen being transferred to the younger and growing part of the plant. Consequently an injection of nitrogen at the base of the plant will bring about a fairly even distribution throughout the plant, for as soon as the older leaves have become saturated under pressure the excess will be redirected by the plant to the younger and less deficient part of the plant, by which time the original solution is diluted. Iron, on the other hand, is a nutrient with very little mobility within the plant and consequently the deficiency of iron occurs first in the young leaves. Heavy concentrations of iron injected into the meristematic points does not often result in redistribution, especially if either the calcium or manganese content of the leaf is high. As a result a heavy dose remains concentrated in one area and excessive damage is caused. Apart from this factor however, the variation in concentration difference required between the major and minor elements needs no amplification.

The degree of deficiency should be taken into account when carrying out injections for diagnostic work. A dose of a nutrient above that required effectively to diagnose a deficiency may set up further complications masking the required diagnostic effects; thus an overdose of calcium may produce chlorotic iron effects, or excess potash may induce slight signs of magnesium deficiency and other toxic effects may also be produced.

The following solutions have been used in direct injection methods:—

1.0 per cent ammonium nitrate.
0.5 per cent calcium nitrate.
0.5 per cent potassium nitrate.
3.0 per cent dicalcium phosphate.
2.0 per cent potassium carbonate.
0.5 per cent magnesium sulphate.
0.5 per cent. calcium chloride:
0.1 per cent boric acid.

0.025 per cent manganese sulphate + 0.025 per cent (by volume) sulphuric acid.

0.1 per cent ferrous sulphate + 0.025 per cent (by volume) sulphuric acid.

0.025 per cent zinc sulphate + 0.025 per cent (by volume) sulphuric acid.

Throughout the experiments described a one per cent solution of acid fuschin has been used as indicator, as its rapidity of action, colour, and ease of washing makes it highly desirable for use. In addition it can be used in combination with chemical compounds to show the path taken by the chemical injected. For this purpose the syringe should be filled with the dye and then emptied, and the dye adhering to the inside of the syringe will then be sufficient to show the path of a liquid subsequently injected by the syringe.

Chemical and Mechanical Damage Resulting from Injections

Damage to foliage may result from the injection of too concentrated solutions or an excess of a low concentrated solution, and the area affected is dependent upon the type of injection used. Chemical damage is most apparent following leaf injections, and in the case of veinal injections it results in marginal scorching and curling either inwards or outwards of the leaf. In an exceptional case of an excessive dose of magnesium sulphate applied to the leaf of a common broad leafed Dock the two halves of the leaf curled over and stuck tightly together. In the case of leaf tissue injections, damage will nearly always occur at the side of the midrib opposite to which the needle is put in, this damage consisting of a small necrotic area generally slightly larger than a pinhead. This, however, has never been known to cause any harm to the injection result. Leaf-fall will result when a leaf is fully permeated by means of the leaf tissue method. In the case of stem injections leaf scorching, spotting or curling will result from an overdose of a nutrient; the type of damage being dependent upon the element injected.

The question of mechanical damage has already been discussed, and it was pointed out that the amount of mechanical damage was dependent upon the length and width of the needle, especially the width. Except in certain cases where leaf veinal injections are made in citrus through the join of the winged petiole and midrib, and occasionally resulting in leaf-fall, no form of mechanical damage has as yet been recorded in using a needle 1/50th in. thick, even when injecting the stalks of newly sprouted potato sets, so that, from the point of view of the needle, mechanical damage is not likely to occur sufficiently to alter the diagnostic results, provided the needle has a diameter no larger than 1/50th in. and is inserted carefully, preferably with a slight screwing action. The other aspect of mechanical damage to be considered is that concerning the internal pressures set up within the plant tissue during the course of injection. As was pointed out previously pressure should be applied steadily and slowly so that a pressure is maintained sufficient for the plant to withstand. High pressures cause excessive leakage around the injection hole which is unnecessarily enlarged, and, in addition, exudation of the injected liquid occurs from the tissues above the injection hole and, though no actual damage to the plant has been observed, it is noticed that plants that are injected in such a way as to cause exudation do not show rapid diagnostic effects, and often do not show results sufficiently conclusive to be taken as a diagnosis. Plants differ in the amount of pressure that they are able to withstand, and this difference is noticed even in plants of the same species; consequently the correct pressure to be applied rests upon the tissue strength of the individual plant which can only be ascertained through experience and knowledge of the "feel" of the plant against the pressure exerted by the syringe.

Time Required for Detection of Diagnostic Effects

The rapidity of diagnosis appears to be dependent upon three main factors: The age of plant; nature of element injected; atmospheric temperature surrounding the plant.

Young plants show reactions to injected solutions quicker than older plants, this being especially noticeable in the case of annuals. In the case of trees and shrubs the youngest, or next to youngest, leaves should be taken for injection as these will give more rapid and distinct responses than will older leaves. Certain elements (e.g. nitrogen), give quicker responses than others (e.g. magnesium). Generally speaking it can be said that the major elements show more rapid responses than do the minor ones. There appears to be an optimum leaf temperature for each species of plant above and below which the rapidity of diagnosis is markedly reduced. Thus greenhouse tomatoes show far quicker results than outdoor ones, whereas orange leaves injected in the cool of the evening show quicker results than similar injections made at midday.

The most dominant factor of these three is undoubtedly the effect of the various nutrients in determining the rate of diagnosis. On oat plants showing typical symptoms of nitrogen deficiency, that is, stunted growth, yellow leaves with older leaves showing tints and thin stems; all injected plants had turned green following an injection of one per cent ammonium nitrate, the diagnostic effects being noticed after five to six hours. In young brassica 24 hours has been sufficient to show effective results in cases of nitrogen deficiency. Maize plants have shown results in nine hours following nitrogen injections on nitrogen deficient plants under tropical conditions. Diagnostic results following injections of phosphate and potash generally take a longer time, especially phosphate, and three to six days is generally required before diagnostic effects are noticed. Calcium has shown diagnostic results on coffee seedlings suffering from calcium deficiency in three days. Iron, the results of which are usually very distinct, generally takes six to eight days to show an alteration in leaf colour though in one instance on greenhouse tomatoes a response was noticed in 36 hours. This, however, is not common and a more general lapse of six to eight days should be allowed before diagnostic symptoms are seen. An alteration in leaf colour following an injection of magnesium on magnesium deficient plants takes about as long as iron with manganese a day or two longer. Zinc may take up to ten days though in one instance an effect was noticed in two-and-a-half days.

In general it can be said that an effective diagnostic result will be noticeable within six hours to ten days, with trace elements taking longer on the whole to react than major ones.

Before it is possible to carry out any form of injection, either by direct or indirect method, it is necessary to be able to recognize some of the symptoms shown by plants when they become deficient in any element. Prior to discussing the results of injections carried out with a hypodermic syringe on various types of plants suffering from many of the more common mineral deficiencies, it may be of interest briefly to describe the common symptoms generally associated with mineral deficiencies. Those wishing to obtain more detailed information on the symptoms exhibited by plants when suffering from a shortage of various nutrients will find more concise information in the reference list at the end of this paper.

Nitrogen.—Symptoms of nitrogen deficiency are fairly widespread and need little introduction to most growers. The usual symptoms on all plants are:—restricted growth of both shoots and roots, thin spindly growth and an upright habit. Leaf symptoms begin first on the older leaves which are usually small and pale green in colour, later developing highly coloured tints of yellow, red and orange. Leaf-fall is premature, especially of the older leaves. Lateral shoots are poorly developed and lateral buds may die or remain dormant.

In citrus, impaired growth and yellowish, sparse foliage are the characteristic condition of nitrogen-starved trees. The tobacco plant, when short of nitrogen, is generally light green whilst the lower leaves turn yellow and cure to a light brown colour. In members of the grass family (e.g. maize, millet, cereals etc.), the dormancy of buds is reflected in poor tillering: some stems show reddish or purple tints and the heads of grain are small.

Growth in cassava is restricted when the nitrogen supply is low, and stalks are generally upright and spindly. The leaves, especially the lower ones, are yellow, often very brightly so, and leaf-fall is premature. Tuber formation is restricted. In members of the cabbage family and most root crops nitrogen starvation is characterized by a dwarfed, thin growth, whilst the younger leaves are pale green and the older ones develop orange and purple tints.

Injections of nitrogen into nitrogen deficient plants produces a renewal of the normal green colour of the leaf in a few hours. In the leaf tissue method the interveinal area injected regains its normal colour after a few hours and in two or three days the area becomes puckered as a result of the increased growth in that part. With the leaf veinal method a renewal of the normal green colour of the leaf is noticed firstly at the base and extreme tip of the leaf, followed by a renewal of the normal colour extending outwards from the midrib and secondary veins. Stem injections result in firstly a renewal of the green colour of the leaves above the injection point, and secondly a recommencement of growth. Except in young plants, or in cases where the deficiency was noticed in its early stages, the tints developed on the stem rarely disappear.

During the course of advisory work in the south of England a five acre field of cabbages was visited: the plants throughout most of the field were stunted and in many cases dying. Root development was poor and all the older leaves were tinted a bright reddish-purple. The youngest leaves showed slight marginal purpling. Three series of plants were injected with nutrient solutions as follows: first series, one per cent ammonium nitrate; second series, 0.4 per cent dicalcium phosphate; third series, 0.3 per cent potassium carbonate. One half of each series, in this case three plants, were injected by the leaf tissue method and the other half by the leaf veinal method. After 24 hours all plants of the first series receiving nitrogen showed diagnostic effects by a renewal of the normal green colour of the leaf in the interveinal area treated by the leaf tissue method, and a general renewal of the green colour in a larger part of the whole leaf area of those receiving the leaf veinal injection. After 36 hours those plants receiving this latter injection had completely regained their normal green colour, following reconversion of the injected nitrogen to other parts of the plant. Neither of series two or three, using phosphate and potash, showed any change following injection. Within 24 hours it was therefore possible to confirm a nitrogen deficiency.

This result is typical of many such experiments using nitrogen. The response is rapid and there is generally little doubt about the results.

Phosphate.—Deficiency symptoms of this element can often be confused with those of nitrogen as there are many points of similarity between them. Thus with phosphate deficiency there is reduction in the growth of both shoots and roots coupled with an upright spindly growth; leaves are small and defoliation of the leaves occurs; growth of the lateral shoots is very restricted. These are similar symptoms to those shown in cases of nitrogen deficiency but a difference exists in that the leaf colour tends to be bluish-green whilst in advanced stages of the deficiency purple tints, bronzing and occasional spotting of the leaf are more common than the reddish tints of nitrogen deficiency.

With tobacco, phosphate deficiency produces a dark, rather dullish, green plant. The lower leaves are yellow and generally cure to a greenish-brown or black colour. The stalk is thin and spindly, while the roots are long and slender with few lateral branches. In citrus the older leaves are first affected by the deficiency, losing their bloom and eventually developing brown necrotic areas following which defoliation takes place. Growth is slow and the tree is stunted. Members of the grass family, grown under phosphate deficient conditions, develop a dark-bluish green colour of the leaves and stems which later develop purplish tints.

Phosphate injections take longer to show a reaction on phosphate deficient plants than does nitrogen on nitrogen deficient plants, and at least three to six days must be allowed before any diagnostic symptoms become visible. These are first seen, in the leaf tissue method, in a renewal of the green colour of the leaf immediately surrounding the injection point, which gradually extends outwards away from the injection point towards the margin of the leaf. In the leaf veinal method the green colour develops away from the main and secondary veins, eventually covering the whole leaf area. Barley plants, showing fairly severe signs of phosphate deficiency, showed an alteration in leaf colour after four days following an injection of dicalcium phosphate at three per cent.

Potash.—Deficiencies of this element are probably more widespread than is commonly believed since in slight cases it may pass unnoticed. Growth is restricted and shoots are generally thin whilst in more severe cases growth is stopped and die-back of shoots and branches may occur. Leaf symptoms are quite distinct when present, the older ones turning a greyish colour followed by marginal scorching, commencing at the leaf tip. Brown necrotic spots are often present especially in the pea and bean family, in the interveinal areas close to the margin of the leaf. The affected leaves often show a tendency to curl backwards along the under surface or roll forwards towards the upper surface.

In bananas and plantains the older leaves show severe marginal scorching whilst growth is severely restricted. With citrus leaves marginal scorching following chlorosis is the most prominent feature whilst the central transverse region turns yellow and the base remains green. In addition small brown spots appear scattered over the leaf though concentrated close to the margin. The leaves may become crinkled and curl towards the under surface. In coffee seedlings the symptoms commence with a marginal chlorosis followed by scorching. With groundnuts interveinal brown spots followed by slight marginal scorching are characteristic. Tobacco leaves are generally mottled with necrotic spots at the tip and margin, which are tucked under. The stalks are slender and in some cases necrotic areas may be present on them as well as on the leaves. The roots are long with few lateral branches and of a slimy appearance.

Injections of potash into potash deficient plants produces an alteration in leaf colour in three to five days. If the deficiency is noticed in its early stages injections of potash will clear off the marginal chlorosis and necrotic spots and bring about a renewal of the normal green leaf colour. In advanced stages of the deficiency, however, when leaf scorch has become severe the symptoms will rarely be altered following injection since the tissue is generally dead. Diagnosis of potash deficiency on cereals, tobacco, tomatoes, potatoes, bananas, coffee, members of the pea and bean family, apples and many other species has been successfully carried out by means of direct injection methods.

Calcium.—Plants suffering from a deficiency become severely distorted in the younger leaves which, in addition, will be either rolled along the upper surface or curled backwards along the under side. The leaf margins often show thin chlorotic bands which later turn brown. The root system is generally greatly restricted. In the field these symptoms are often complicated by the effects of acidity and manganese toxicity.

Coffee seedlings, deficient in calcium, show a marked white band around the leaf margin whilst the root system is poorly developed and the plant can be easily removed from the soil. In tobacco the young leaves become distorted and die-back occurs at the tips and margins of the leaf giving it a "cut out" appearance. The roots are short, dark brown in colour, and more or less decomposed. Citrus leaves show a chlorosis characterized by a yellowing of the veins, followed by leaf scorching and die-back.

Systematic injections for the diagnosis of calcium deficiency generally take three to five days to show an alteration in leaf colour. Coffee seedlings, showing marginal chlorosis in the form of a white band along the margin, together with necrosis of the leaf tip, were divided into three series, the first receiving an injection calcium nitrate (1 per cent), the second potassium nitrate (0.5 per cent) and the third distilled water. Within three days it was possible to discern an alteration in leaf colour of the series receiving calcium nitrate whilst those receiving potassium nitrate and distilled water failed to show any response following the injection. After ten days the calcium series had completely regained their normal leaf colour and growth rate, whereas the potassium series had shown very severe leaf scorch as a result of the excess potash. Both the potash and distilled water series were dead within six weeks of the time of injection.

Magnesium.—Since magnesium is a constituent of chlorophyll it is not surprising that deficiencies of this element result in a chlorosis of the leaf, commencing at the eldest ones and proceeding systematically towards the younger ones. Chlorotic effects however are not the only result of magnesium deficiency and brilliant tints are often produced, whilst defoliation is severe.

The oldest leaves of tobacco show chlorotic effects, and a rolling inwards along the upper edges. In the early stages of magnesium deficiency on citrus, yellow areas develop between the secondary veins and on either side of the midrib of the leaf. These gradually enlarge and coalesce producing a general yellowing, first at the base and later over the entire leaf. Defoliation is not as severe as in other clases of fruit (e.g. apple). Broad leaved crops, such as brassica, are very susceptible to the deficiency, and, apart from the early effects of interveinal yellowing, brilliant tints of orange and purple are produced.

Injections of magnesium sulphate into magnesium deficient citrus leaves produces a renewal of the green colour within six to seven days. The leaf tissue method produces a dark green patch in a semi-circular ring immediately opposite the injection point. The veinal method on the other hand, produces a renewal of the green colour, first along the midrib and veins followed by a gradual reversion to the normal green colour over the whole leaf starting at the base. In greenhouse tomatoes in parts of England magnesium deficiency has been a serious factor, in some cases rendering the crop a total loss. Injections of magnesium sulphate either by the leaf tissue or leaf veinal method has been successfully used in the diagnosis of this deficiency. In this case it is no use injecting plants in the final stages of the deficiency as these will rarely show a response, but in the early stages of the deficiency an injection will produce an alteration in leaf colour in about five days.

Iron.—The main symptom of iron deficiency is always a chlorosis, commencing on the younger leaves. The veins generally remain green but in severe cases the newly opened leaves may be completely bleached. The deficiency appears to be more prevalent on fruit trees than on normal farm crops, an exception to this being the tomato, the younger leaves of which commonly show an interveinal chlorosis, sometimes of a mottled nature but more generally as a distinct chlorosis, with the veins, at the base of the leaf, standing out green against the chlorotic background.

Lack of iron in citrus leaves produces a chlorosis of the younger leaves in which the ground tissue remains yellow while the veins are green, until, at a later stage, the whole leaf may assume a light yellow or cream colour and only the midrib retaining any green colour. In tobacco, iron deficiency produces a chlorosis of the younger leaves with the veins remaining green.

During the course of advisory work in the south of England a number of glasshouses were visited where iron deficiency on tomatoes was present. Injections of ferrous sulphate were made by both the leaf veinal and stem method and diagnostic results were recorded within 36 hours from the time of the injection. The effects noticed were a renewal of the normal green colour of the leaf spreading outwards from the midrib and main veins. Iron injections on citrus by the leaf tissue method, produce a small necrotic spot about the size of a pinhead close to the midrib adjoining the final resting place of the needle when in position for the injection; around this necrotic spot, in a semi-circular patch, an alteration in leaf colour is noted by a renewal to the normal green colour. This semi-circular patch, as in all leaf tissue injections, is concentrated within an interveinal area so that the two interveinal areas on either side of the treated one remain chlorotic and serve for comparative purposes.

Manganese.—Symptoms of manganese deficiency vary considerably though they generally consist of chlorosis of the leaves.

In citrus the deficiency resembles that of iron deficiency and injections of manganese sulphate, by the leaf tissue method, have brought about a renewal of the normal green colour in eight to nine days in a manner similar to that described for iron deficiency. In tobacco the young leaves are chlorotic with necrotic spots over the leaf. Oats are the most common sufferers of manganese deficiency on certain types of soil, when a disease known as Grey Speck occurs. This appears during the first phase of the plant's life, generally when about six to seven inches in height. The oldest leaves turn yellow at the base and greyish streaks appear, usually most severe near the margins of the leaf. These streaks eventually elongate and coalesce and the affected tissue turns brown. The leaves finally break over at the upper end of the seriously affected part and hang down limply. Once the plant has reached this stage stem injections of manganese sulphate have no effect, but if injections are done whilst the streaks occurring in the leaf are still in the greyish state and the tissues have not yet turned brown a correction of the deficiency can be obtained.

Zinc. — As with iron and manganese deficiency the first signs of zinc deficiency are an interveinal chlorosis, though in many plants, especially trees, an abnormal type of growth known as rosetting occurs.

In citrus the first symptoms of the deficiency are revealed in a mottling or interveinal chlorosis, generally commencing on the younger leaves. As the deficiency becomes more acute the intensity of the chlorosis increases, multiple buds develop, and the shoots eventually die. White bud disease of maize is attributed to zinc deficiency. In this disease yellow streaks appear between the veins of the older leaves and as the younger unfold they are often of a white or yellow colour. The streaks on the older leaves develop into necrotic areas and the leaves eventually die. Death of the whole plant may ensue in a few weeks.

A deficiency of zinc in groundnuts was noticed by the writer in which the groundnuts showed a very marked and total chlorosis of the leaves which, in addition, were all produced on a much reduced stem giving the plant a rosetted appearance. In the diagnosis of this particular deficiency two sets of plants were taken, one receiving an injection of 0.1 per cent ferrous sulphate and the other 0.25 per cent zinc sulphate. After three days those injected with zinc sulphate showed a slight renewal of the normal green colour of the leaf along the sides of the midrib and especially at the apex of the leaf. Within five days the leaves had turned noticeably greener. No effect was noticed from the injections of ferrous sulphate except that a marginal scorching was apparent four days after being injected and the plants withered up and died. From the results of these injections it was considered that the original visual diagnosis of zinc deficiency was correct, and this appears to be the first case recorded of zinc being essential for the normal growth of groundnuts under field conditions.

Leaf injections of citrus for the diagnosis of zinc deficiency does not appear to be as rapid a method of diagnosis as spraying the foliage. In maize plants grown in sand culture zinc deficiency symptoms, as described above, appeared after five-and-a-half weeks of growth and the plants were then injected, through their adventitious roots, with a solution of 0.025 per cent zinc sulphate. Three days after the injection a marked improvement of leaf colour was noticeable in the youngest leaves, and subsequent growth developed normally. The oldest leaves developed necrotic areas however and finally withered up completely.

Boron.—A deficiency of this element has not as yet been seen by the writer in the tropics though it is of common occurrence in England and many other parts of the world on certain types of soil. The deficiency is characterized by an interruption in the normal development of the growing point of the plant whilst the stem and leaves show severe distortion. In addition leaves are often scorched and, apart from the curling may show some form of mottling. The central pith and epidermis of the stem are affected also resulting in a hollow and rotten stem following bacterial infection of the affected tissues. Fruits are severely deformed and generally useless for market purposes.

Brassica and other root crops appear to be the crops most severely affected by the deficiency. In plants such as cauliflower and kale external symptoms consist of restricted growth of the growing points, distortion of the leaves and, in cauliflowers, discoloration of the curd. In both plants the stem is generally hollow. With sugar beet and its related plants, death of the crown leaves occurs and the crown may be covered with small, deformed leaves, whilst the older leaves become scorched and die. The root itself generally rots, and, though no outward signs of the rotting may be discernible, the root, when kicked by a boot will break up into a rotten pulpy mess.

In citrus, Haas and Klotz describe the symptoms of boron deficiency as a splitting and corking of the midrib of the leaf, causing the leaf to curl downwards at right angles to the midrib. Such leaves take on a lustreless and bronzed appearance. In severe cases a multiple bud form may develop. The bark and shoots split in the internodal regions and gum is exuded. The fruit show dark mottled areas in the albedo and a thick rind.

Injections of 0.1 per cent boric acid into boron deficient sugar beet whilst in both the young and early stages of the deficiency, and growth, brought about a recovery in the distorted growth of the crown leaves and new healthy growth was put forth.

INJECTIONS AGAINST DISEASES OTHER THAN NUTRITIONAL

Since the early ages efforts have been made to inject plants with substances designed to cure them from some parasitic disease, the results of which have nearly always been crowned with varied, and often doubtful, success. In view of the wide use of the hypodermic syringe in medicine, it is perhaps only natural that efforts should be made to use it to combat bacterial and other parasitic diseases of plants. Results, however, are so far neither conclusive nor encouraging, though one experiment is worthy of note. A series of cuttings were taken from mosaic infested cassava plants and planted in pots. After germination the plants were allowed to develop mosaic until infection was present on all leaves six weeks after germination. A series of injections of a five per cent solution of 8-hydroxy quinoline potassium sulphate were then carried out by means of stem injections. The first injection, six weeks after germination, was followed by three more at intervals of ten days between each, the total amount injected per time not exceeding ½ c.c. A very marked improvement in the reduction of the mosaic was seen to take place following each injection. Eight days after the fourth injection all leaves had recovered from the mosaic, and except for showing slight yellowing where the mosaic had affected them, were otherwise quite healthy. Untreated, control plants were, by then, heavily infected with mosaic. It is hoped however to carry out more extensive experiments on these lines against mosaic infection of tobacco.

TABLET INJECTION METHODS

All the diagnostic injections made by syringe on the leaves of trees and shrubs have been corroborated by means of tablet injections, and it may therefore be of interest to give a few notes on this method of injection.

The method was originally developed by S. P. Bennet of the University of California Agricultural Experiment Station, and described by him in their Circular No. 321 of March, 1931, since when, it has been more fully developed by other workers, notably C. R. Thompson. The principle of the method is to inject into a hole in the trunk of a tree one or more tablets containing the element in which the tree is deficient, the hole being then blocked with a leather plug. The equipment required consists of a "pill-pusher", a brace and bit, and a leather punch. The pill-pusher is nothing more than a hollow steel tube, the internal diameter of which is ½ in., but tapered slightly at the end. A round solid steel plunger fits inside the steel tube; the plunger having a handle fitted and being a little longer than the steel tube. Operators should have two plungers; one that protrudes ¼ in. beyond the steel tubing and the other protruding ½ in. beyond the tubing. An Irwin pattern bit is required for the brace with a diameter of either ½ in. or ¼ in. depending upon the size of the tablets being used. It is essential that the bit should have two very sharp cutting edges at the extreme end of the thread. A leather punch is useful for cutting out the lino or cork discs with which to block the hole after the tablet is in place. The tablets, or pills, are 7/16ths in. in diameter supplying 1 gram of salt and costing approximately Sh. 12/6 per thousand. For trees of less than 3 in. in diameter tablets of ⅛ gram are used.

Theoretically injection holes should be bored three inches apart, or about one hole for every one inch diameter of the stem, but the placing, and number of holes is dependent upon not only the size of tree, but degree of deficiency and type of nutrient to be used, and can only be learned by experience. For a general guide the following table should be used, the dose in each case lasting for two to four years.

Diameter of Stem in inches	Number of tablets per Hole	Total Number of Holes
3 in.–6 in.	1	3–6
6 in.–10 in.	2	6–10
10 in.–20 in.	3	10–20

The tablets should come to rest next to heart wood and not next to bark or sap wood. The plug should be firmly and cleanly lodged in the hole and sufficient space left for growth to take place over the bark.

SUMMARY

The use of a hypodermic syringe for plant injections in the diagnosis of mineral deficiencies is described, and it is shown that patience and experience, with relatively little technical skill, is required and that results are obtained rapidly and with a high degree of accuracy.

The advantages and disadvantages of the methods used are discussed, and it is found that in practice few disadvantages occur in using a hypodermic syringe for plant injections on a large number of both temperate and tropical species of plants.

The types of syringes most useful for injection purposes are described and the additional equipment required is listed.

Three principle methods of injection are described, two referring to leaf injections and one to stem injections. One leaf method, involving the permeation of all major and minor veins by the injected solution, is conveniently termed the leaf veinal method, whilst the other method involves the permeation of the tissue of an interveinal area of the leaf and is conveniently called the leaf tissue method.

The methods of injection most suitable to various common species of plants are discussed as a guide to the adaptation of the theory to practice.

It is found that the methods of injection, especially the leaf tissue method, for the diagnosis of mineral deficiencies attains a degree of accuracy rarely attainable in either experimental or diagnostic work.

The type and strength of chemical solutions used for injections are given, and the effect of both chemical and mechanical damage described.

A brief outline of the symptoms attributed to deficiencies of some of the major and minor elements is given, and the results of typical injection experiments described.

As far as possible all details relating to the physiological aspect of the injection methods are omitted, so that this paper refers only to the type of injections as used solely in diagnostic work, and it does not attempt to give the more complicated details necessarily associated with such injections.

Reference is made to the use of a hypodermic syringe for injection purposes in the control of mosaic virus on cassava.

A short note is given regarding tablet injection methods.

ACKNOWLEDGMENTS

I would like to take this opportunity of acknowledging the help given to me by Dr. N. H. Pizer, Advisory Chemist to the South Eastern Agricultural College, Wye, Kent.

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CORRESPONDENCE

The Editor, East African Agricultural Journal.

SIR,

I cannot refrain from commenting on the quotation from "Farm and Forest" which appears in the April number of this Journal. The sentiment expressed appears to be largely —sentiment. A few months ago I was lecturing on the Economics of Soil Conservation at the Egerton School of Agriculture when a student interjected "But surely agriculture is not a business!" There appears to be something of the same feeling about your extract.

Until we get away from sentimental "blah" about agriculture being a "way of life" we shall not have much chance of raising living standards of the masses or of protecting the resources of the soil. Efficiency in production is essential if agriculture in any country is to play a part in international trade and to compete on favourable terms with other countries. Where man power is frittered away on subsistence agriculture on petty holdings, where no mechanization of any description is economically or physically feasible, there is no hope for industrialization, in any case, owing to lack of labour and the high cost of food whether in terms of cash or man power. Russia soon realized that under such conditions there is also no possibility as a rule of attaining any sufficient standard of living or nutrition.

It is fairly safe to generalize that the lower the living standard of a country the higher the proportion of the population which will be found engaged in agriculture. The underfed millions of India and China present the most notable example of this with some 90 per cent of the population supporting themselves by agriculture in both countries. Whether the peoples of these countries are really happy when they are dying of famine, drowning by floods from eroded high lands, or merely suffering from gnawing pains in their hollow bellies, is open to question. Happiness is a very abstract criterion and it obviously means something different to every individual; to many Africans it represents a passive contentment born of indolence in uncultured poverty, whereas lack of occupation to a restless Western European frequently means boredom leading to melancholy—or in the vernacular —being "browned off"!

It is usual to assume that an ample, varied and nutritious diet coupled with an adequate standard of clothing and housing, together with sufficiency of leisure, are sound foundations upon which to build good health; and good health if not a necessary factor for happiness may be considered as generally a favourable indication towards it. Whatever is the current sociological thought on the West Coast it is realized more and more widely on the East Coast of Africa that such an aim can only be achieved by a higher output per head of the farm population. This demands an increased degree of mechanization, employed in a more advanced technique of husbandry, and, frequently, the movement of many families from the land to give the remainder elbow room. Where populations are overcrowded, industrialization is one of the most hopeful means of absorbing surplus people and of promoting local markets. Alternative settlement areas are often scanty or dubious in value. Under the overcrowded conditions in parts of Africa it is unlikely that each country "can be agricultural or mainly so and at the same time hold its own in the world and bring great happiness to its people". Continuance of belief in this philosophy means ever-growing populations in areas which grow more and more impoverished and so are liable to be subject to famines of greater and greater frequency leading not to Arcadian or bucolic happiness but to famines and malnutrition. This is more likely to sum up to misery.

Denmark is mentioned as exemplifying the prosperity of primarily agricultural countries. This is too facile an assumption. Denmark is admired by the world for her co-operative agricultural enterprises, for her well developed educational system—including the excellent Folk High Schools—and for the capacity of the Danes to adjust themselves intelligently and rapidly to changes in the economic scene. But it is only their very intelligence, education and democratic organization which has enabled Denmark to weather various economic crises due to their dependence on the export of agricultural products. These qualities are as yet undeveloped amongst most of the African peoples.

Mr. Lamartine Yates, in his book *Food Production in Western Europe* (1940) wrote:—

> "The world economic depression plunged Denmark into grave difficulties. She is a nation with no overseas possessions, with no mineral resources at home and entirely dependent for her economic well-being on foreign trade. With her exports, four-fifths of which were agricultural commodities, she paid for her raw materials, for imported manufactures and also, being a debtor country, the interest on her loans. The more her exports increased, the higher the standard of living she could enjoy. Her exports of agricultural commodities rose from 247 million kroner in 1900 to 1,219 million kroner in 1930. Then came the check. From 1930 to 1932 they fell by about 300 million kroner or 25 per cent. This was the primary difficulty which had to be circumvented; it was this decline in exports to which the whole national economy had to be readjusted."

Foodstuffs, indeed, "have always been cheap" in Denmark and "Danish families did not need to spend anything like such a high proportion of their *total income* on foodstuffs as the British". Nevertheless, in pre-war days—the post-war position presumably is favourable for the next few years—Denmark had to "look forward to a smaller quantum of foreign trade than in the period 1925-30 and, accordingly, she must shape her economy on somewhat autarchic lines. If she cannot export so much, she will have to manage with rather less raw materials or manufactured goods." In fine it must be considered that Denmark is an example of how intelligence and industry can overcome natural disadvantages—even much of her soil was initially poor—not a recommendation for embracing difficulties due to lack of raw industrial materials which necessitated a considerable dependence on agriculture; but even in Denmark, farming provides the livelihood for only one third of the occupied population "which is a high figure for Western Europe." Compare this with Africa, India and China. Let us turn from the highly industrial United Kingdom with only 5.7 per cent of the working population in agriculture—and a generally high standard of living excelled probably by that in the U.S.A. alone—and from Switzerland also with well developed industries and only 20.1 per cent of the working population engaged in agriculture—to consider Poland with 72.3 per cent and Bulgaria with 80.0 per cent agriculturists respectively. Here we should find an agrarian content unmarred by the evil influences of mass production. The Polish farmer, however, can obtain at best a money income one-sixth of that of a Danish peasant. Yields are falling owing to pressure on the land. "Of the total peasant population of Eastern Europe of 60 millions, probably one-fourth do not produce enough to satisfy their need for food, in the sense of bread" (*Economics of Peasant Farming*: D. Warriner, 1939). In Poland, as in Africa, the time before the harvest is a time of distress which is known as "the hungry months". In the over-populated districts of Jugoslavia "Till Christmas or till March they can supply their own need for bread; and afterwards eat their goats, wild grasses, weed, to exist till the next harvest". In Bulgaria a sharp fall in incomes of the rural population compared to town dwellers "is a result of the change in world conditions, the increased productivity of agriculture overseas and clearly the only way in which adjustments to the change can be made is by a reduction of the number of people engaged in agriculture, above all in corn growing. Only if the peasants could move into industry or into other branches of food production for which the demand is more elastic—such as fruit, vegetables, oil plants and industrial crops —is there any hope of arresting the decline in the standard of living".

Unfortunately, books of the type of those from which I have just quoted do not give any information as to whether the peoples of the Eastern European countries which are mainly agricultural, are compensated for their material difficulties by the enjoyment of great happiness of a more spiritual nature.

Yours, etc.
COLIN MAHER.

The Editor, East African Agricultural Journal.
SIR,

I have read with interest the article in your April issue on phormium fibre, by Mr. Wigglesworth, of London, and offer these comments:—

Any comparison between Kenya and New Zealand, as to production costs, is quite out of the question; the two countries differ too widely in climate, labour conditions, soils and government. Mr. Wigglesworth gives the impression that he regards the whole future of phormium as bound up with the fortunes of sisal, with which he assumes phormium will be in competition. I submit that this is not necessarily so. It is true that phormium is put to much the same uses as sisal, to which it is inferior in strength and adaptability to combing. But it is also true that it is used for certain purposes to which sisal is either ill-adapted or not adapted at all. Your article completely ignores the crop's relation to the means of the small farmer, its use as a deterrent of erosion and as an improver of the soil, and the comparatively low cost of machinery.

The political situation in India offers small hope for unlimited supplies of jute at a reasonable price, in the foreseeable future. It would seem the part of wisdom to encourage the growth of at least such supplies of suitable fibres, as to make the three territories independent of any outside source. It is encouraging to note that a fair number of farmers in the Kenya Highlands have sufficient faith in their own judgment to take the lead and the risk in developing what may well prove to be of great service to East Africa.

Yours, etc.
W. L. JACKSON.

The Editor, East African Agricultural Journal.
SIR,

Your correspondent Mr. Jackson is correct in pointing out the difference in producing Phormium Tenax in Kenya as compared with New Zealand, since there is reason to expect production costs to be lower in East Africa. He also rightly explains the relative softness of phormium in contrast to the hardness of sisal and manila hemp. There are, however, grave doubts as to the ability of phormium to compete with either of these fibres for rope and twine unless produced and sold substantially cheaper than sisal, nor can phormium easily compete with jute for hessians, bags, woolpacks, etc.

The present famine in both cordage fibres and jute is temporary. Jute for instance may crop 9,000,000 bales this year as against 5,000,000 last year. I would repeat my note of warning that exact knowledge of the cost of production and other problems involved are essential before venturing into large scale cultivation in Kenya. If, after careful trials, it proves economically feasible, the East African phormium industry will be welcome as a potentially valuable addition to the range of Empire fibres.

As regards the crop's relation to the means of the small farmer and as a deterrent of erosion and an improver of soil, obviously all these factors are ancillary to the main point, which concerns whether the crop can be made a profitable proposition or not. Regarding the political situation in India it would be entirely premature to forecast that this, however it may turn out, is going to interfere seriously with the jute crop which is the mainstay of the economy of Bengal.

Yours faithfully,
A. WIGGLESWORTH.

THE AFRICAN ALPINE BAMBOO*

By S. H. Wimbush, B.A., Dip.For. (Oxon) (Assistant Conservator of Forests, Kenya)

The alpine bamboo (*Arundinaria alpina* K. Schum.) is a medium-sized, strong but thin-walled bamboo which grows gregariously in mountain forests in tropical Africa. It is found in the highlands of Abyssinia, the southern Sudan, the Congo, Uganda, Kenya and Tanganyika. Even as far south as Nyasaland a species of alpine bamboo believed to be *Arundinaria alpina* has been found.

Distribution

In Kenya it forms dense forest, covering the mountain slopes at an elevation of 8,000 to 10,000 feet above sea level. The largest areas of bamboo forest are on the Aberdare Range (250 square miles), the Mau Range (200 square miles) and Mount Kenya (150 square miles). Smaller areas are found on Mount Elgon and the Cherangani Hills. Bamboo is found on most East African mountains above 8,000 feet, but it is a remarkable fact that there is none on Kilimanjaro, Africa's highest mountain, on the Kenya-Tanganyika border.†

Size

The alpine bamboo attains a height of 60 feet with a diameter up to 4 inches. Its average size is 45-50 feet high and 2½ inches diameter. An acre of bamboo forest may hold 4,000 to 7,000 stems. If these are cut the yield of air-dry culms is about 40 tons in weight. As the culms grow evenly-spaced and not in tight clumps, as with most bamboo species, they are very straight.

Uses

In Kenya the use of bamboo is mainly confined to temporary buildings and palisade fencing. Its particular combination of strength with lightness, straightness and hardness, as well as its hollowness and the ease with which it can be split, make it suitable for a variety of purposes. Pulp manufactured from it gives a high-class paper and should be a valuable source of cellulose. The average cellulose content of the air-dry bamboo is 47.5 per cent.

Method of Growth

Bamboo is a grass. In Kenya it is evergreen, but sheds its older leaves, which thus provide a dense litter covering the soil. Its habit and structure are similar to those of other grasses of upright habit, on a larger scale. Its method of growth is by the elongation of the internodes, which before developing are as it were telescoped into an inch or two in length in the bud.

Growth begins some weeks after the onset of rainy weather, and it continues apace for one to two months. At the end of this time the full height and girth of the bamboo has been reached. The growing tips of the young culms are eaten by Syke's monkeys, bush-buck and elephants, but not (so far as the writer is aware) by natives. In that part of Kenya subject to orographical or "monsoon" rainfall the growing season is approximately from mid-April to the end of June. New bamboos have also occasionally been observed growing in January, following heavy rainfall in November and December. The thin branches and leaves do not develop until after the stem has finished its height growth. The stem grows no more in height or thickness after the first season. These aerial culms spring from the underground portion of the stem of the plant, known as the rhizome, which grows in the same way as the culms, but horizontally and on a much smaller scale, its growth in a single season being inches rather than feet. The rhizome provides the mechanical anchorage for the bamboo plant, and the nutritional functions are carried out by the true roots which are thin and fibrous growths springing from the nodes of the rhizome.

As every bamboo plant spreads by the underground extension of its rhizomes from which aerial culms or "bamboos" spring, it tends to assume the formation generally referred to as a clump. In forest of alpina bamboo the clumps spread widely and intermingle with neighbouring clumps. The early tight formation of the clump becomes lost as the older culms at its centre die and disappear. They are replaced by new culms which spring from the extensions of the old rhizomes, but these new culms are more widely spaced and the continuation of this process over a long period tends to obscure the clump effect and gives a homogeneous appearance to a bamboo forest.

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* Reprinted from the *Empire Forestry Journal*, Vol. 24, No. 1, 1945.

† There is no published record of bamboo on Kilimanjaro, but the Tanganyika Forest Department know of one small patch (only fifteen acres) on the west side. The rarity of the bamboo on Kilimanjaro is all the more remarkable because it is so abundant on Mt. Meru, only thirty miles away.

Growth of New Culms

New culms are continually springing up and old culms dying, and the natural balance of growing bamboos is thus maintained at a more or less constant number in the virgin forest. It will have been noticed by any one who has known a bamboo forest for a number of years that production of new culms may be prolific one year and sparse in another year, even to the extent of complete barrenness when no new culms appear at all. Production of new culms observed in two plots in the Kikuyu Escarpment forest on the Aberdare Range during the past twelve years is shown below:—

Production of New Culms Per Acre

Year	Annual		Three-Yearly Periods		
	Plot 1	Plot 9	Years	Plot 1	Plot 9
1932	73	Not counted			
1933	28	"	1932-34	1,423	—
1934	1,322	"	1933-35	1,350	—
1935	Nil	"	1934-36	1,336	—
1936	14	20	1935-37	1,239	—
1937	1,225	2,064	1936-38	1,358	2,396
1938	119	132	1937-39	3,401	3,872
1939	2,057	1,676	1938-40	2,176	1,808
1940	Nil	Nil	1939-41	2,463	1,784
1941	406	108	1940-42	1,100	944
1942	694	836	1941-43	2,068	1,400
1943	968	456	Average	1,791	2,034

From the first three columns it can be seen how greatly production of new culms varies from year to year. A year of prolific production of new culms numbering 1,200 or more per acre is always followed by poor, or even no, production of new culms in the succeeding year. Generally the second year after a year of prolific growth is also a poor one, though the year 1939 was a notable exception to this. The last three columns compare the number of new culms produced in three-yearly periods. In both plots the most prolific production was in 1937-39, and the poorest in the period 1940-42. The average number of new culms produced in three consecutive years was 1,791 culms per acre in plot 1 and 2,034 in plot 9.

These observations on seasonal fluctuations of reproduction refer to mature bamboo forest where no cuttings or other interference is taking place.

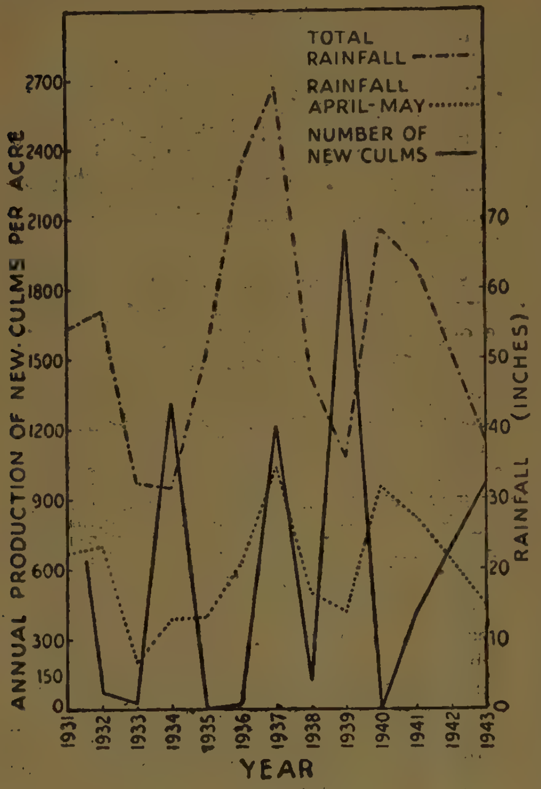
This fluctuation is much less marked in areas where bamboos have recently been cut. In the growing season following cutting there is always a more or less vigorous reproduction of new culms, irrespective of whether the season is or is not a productive one in the uncut bamboo forest. As these cut areas gradually become restocked with bamboo, so they conform more closely to the periodicity of reproduction in the uncut forest, until normality is again reached. This may take seven to nine years (*see Recovery of Bamboos after Cutting*).

Factors Influencing Production of New Culms

There appear to be certain conditions under which production of new culms will occur in virgin forest of alpine bamboo. It appears likely that when climatic conditions have been favourable over a period for storage of food in the rhizome and for the formation and development of buds (culms in embryo) production of new culms will ensue. Ample soil moisture, and therefore good rainfall, are the first requisite of this period, during which storage is taking place. The length of time required for the rhizome to accumulate sufficient food reserves to launch a period of active growth depends partly upon the degree to which reserves were depleted by the previous flush period, and partly on the rate at which plant-food is manufactured, which may be expected to be controlled by the rainfall. After a period of prolific growth of new culms which has drained the food reserves of the rhizome it generally appears to take three years for sufficient replenishment to induce another production of new culms, but this period may be shortened to two years if abnormally high rainfall is experienced during the first year of dormancy.

Abnormal drought may result in only sparse production when new culms again appear, but does not seem actually to lengthen the period of dormancy.

These points are illustrated in the accompanying diagram showing the production of new culms in the Kikuyu Escarpment forest (Plot 1) from 1931 to 1943, compared with the total annual rainfall and with the rainfall during April and May.



LIFE OF A BAMBOO CULM

The length of life of a bamboo culm is not yet definitely known. In a plot in bamboo forest which has been kept under observation for the past nine years the oldest culms are known to be over ten years old. During the period of observation the number of living bamboos in the plot remained fairly constant, the number of culms that have died being roughly equal to the number of new culms which have sprung up. The number of culms which have died annually has on the average been one-fourteenth of the total number of culms, and it may well be, therefore, that the length of life of a bamboo culm in this particular locality is on the average fourteen years. Only 9 per cent of the culms which grew nine years ago have died so far in this plot: these are the oldest culms whose age is definitely known.

A rough guide as to how to tell the age of a bamboo by its appearance is given below:—

Plenty of moss on the weather side and generally some lichen .... *8 years or over.*

Some moss on nodes and internodes, but little or no lichen. Grey blotches, roughly circular and as big as a sixpence, on the internodes .... *5-7 years.*

A little moss at nodes only. Little round grey flecks, smaller than a threepenny bit, on the internodes. Stem is scrubby to the feel, not smooth .... *3-4 years.*

No moss on stem. Colour pale green, with small orange flecks on the lower part of the internode (looked at closely). Surface smooth and distinctly "downy". "Velvet" at nodes grey-brown. Generally has the remains of the sheath still persistent on the lowest node, but it is dirty and ragged ...... *1-2 years.*

Dark even green colour all over, with a rich brown "velvet" at nodes. Very smooth and "downy" stem. Generally has at least the two lowest sheaths persistent on the stem, and at six months old sheaths will still be persistent on some of the upper nodes also .... *Under 1 year.*

LIFE CYCLE OF A BAMBOO PLANT

When a bamboo plant flowers and produces seed it has come to the end of its life, and after seeding it dies, a new crop of bamboos springing up on the area from the fallen seed. However, in an area that had seeded and died five years previously, investigation of the underground rhizome of a young clump about a foot across, consisting of a dozen thin canes a few feet in length and one 10 ft. culm which had just grown, showed that this clump had not originated from a seedling but was plainly connected with the old rhizome system. It seems possible, therefore, that the end of the life-cycle of the bamboo may not always result in the complete death of the plant, but that a last-minute recovery of vegetative vigour may occur. F. A. McClure found the same thing to occur in the Chinese Tea Stick Bamboo or Tonkin Cane (*Arundinaria amabilis*). He says: "The plants which flowered did not die, however, but exhibited a progressive suppression of vegetative activity lasting over a period of several years . . . Plants secured while in the height of their flowering condition have, after three years of flowering under observation only now begun to recover their vegetative vigour". ("Studies of Chinese Bamboos", F. A. McClure, *Lingnan Science Journal*, Vol. 10, 1931.)

There is evidence that the life cycle of the alpine bamboo is more than 40 years in the particular locality on the Aberdare Range where a series of plots are under observation, but whether it is much longer, or whether it is shorter, in other places is not known. In the case of the common bamboo *Dendrocalamus stricta* in India it is known that the life cycle varies from twenty to forty years in different localities, but that it is more or less constant in any one locality (*Indian Forest Records, Silviculture,* Vol. II, No. 4).

The flowering, seeding and dying of the alpine bamboo occurs gregariously in Kenya, but not on the vast scale experienced with some kinds of bamboo in other countries where whole districts are sometimes affected. In Kenya flowering is known to occur in patches of one to ten or more acres, extending over several hundred acres of bamboo forest at a time, but so far no case of any more extensive gregarious flowering has been recorded.

RECOVERY OF BAMBOOS AFTER CUTTING

When an area of bamboo is cut, new shoots appear, springing from the old rhizomes. If at the time of cutting every bamboo is cut, the new shoots that come up in the following growing season are thin, leafy and only about 6 ft. high. The new shoots of succeeding growing seasons are progressively thicker and taller until eventually normal full-sized culms spring up. From observations in the Kikuyu Escarpment forest in plots that were cut eleven years ago it has been found that normal full-sized culms may appear in the eighth or ninth year after clear-cutting bamboos on a fairly level site, but that on steep slopes where the soil dries out more rapidly than on level sites several years more may elapse before full-sized culms are produced.

If, however, some of the old culms are left standing at the time of cutting, it appears that this period of recovery may be shorter by one or more years, depending upon the number of old culms left standing. If 10 per cent of old culms are left standing, evenly distributed on a level or gently sloping site, full-sized new culms may appear in the seventh or eighth growing season following cutting. If, however, 50 per cent of the number of culms are left standing evenly distributed the recovery period may be as short as three or four years.

CUTTING CYCLE FOR BAMBOOS

The cutting cycle is the period that must be allowed to elapse between two successive cuttings of an area of bamboo. It will be governed by the length of the recovery period, to which must be added the number of years that is needed to produce a full complement of normal bamboos. A complete stand of bamboos is normally about 5,000 culms per acre. It has been found that on the average 1,800-2,000 new bamboos per acre are produced every three years. Six to nine years must therefore be added to the recovery period to arrive at the proper cutting cycle for bamboos. In a clear-cut area the cutting cycle will be not less than 8 plus 6 equals 14 years, and may be as much as 12 plus 9 equals 21 years on poor sites where the recovery to normal full size is delayed.

If, however, 10 per cent of the bamboos are left standing evenly spaced at the time of cutting, the cutting cycle may be reduced by one or two years.

These cutting cycles will apply to extensive cutting operations where large quantities of bamboos are needed. On farms, where the area of bamboo forest is not large and where cutting is spasmodic, the owner will probably find it more convenient to work the bamboo on a short cutting cycle, dividing his forest into five blocks. He can then allow cutting in a single block each year, in rotation, and provided that he does not allow more than 50 per cent of the old culms in each group or patch to be cut, the size and quality of the bamboos available will not deteriorate.

CUTTING SEASON FOR BAMBOOS

Bamboos may be cut at any time of the year except during the growing season, without affecting the length of time required for recovery of full vigour by the plant. It has been found that if bamboos are cut during the months of April, May and June in the Kikuyu Escarpment forest there is no new growth during that season and the recovery period is lengthened by several years.

Bamboo forest in climatic areas similar to the Kikuyu Escarpment, i.e. east of the Rift Valley, should therefore be closed to all cutting during the months of April, May and June.

BURNING SLASH AFTER CLEAR-CUTTING

Experiments carried out on a number of plots in the Kikuyu Escarpment forest showed that a severe burn on a felled area will kill outlying younger rhizomes of a clump (thus emphasizing the "clump" effect), but that the recovery period is not thereby lengthened. A severe burn retards subsequent growth of herbs and grasses, but a light burn seems to stimulate them. It is important to re-establish a soil cover as quickly as possible after clearing an area of bamboo, and a severe burn would therefore be harmful where a light burn would be advantageous. The value of early burning is to reduce the danger from fire later when re-growth has begun to appear.

MAKING A BAMBOO GROVE

If seed is collected from bamboos at the conclusion of the flowering stage, it will germinate readily if sown in nursery beds and watered daily. The seedlings should be transplanted into soil-boxes or other nursery beds when about one inch high. It takes about eight to twelve months from the date of sowing the seed for good-sized transplants to be obtained. If these are planted out in wet weather at intervals of 6 ft. they will form clumps which will join up to form a continuous grove of bamboos in five or six years time. They will then be producing a number of culms every season, the largest of which may be 2 inches in diameter and 40 feet in height, provided no cutting has been allowed in the clump. Bamboos will grow readily in Kenya in good soil on well-drained sites (*not* in swampy land) at altitudes over 7,500 feet. If only a few plants are wanted, one-year old culms with a portion of the rhizome may be separated from existing clumps of bamboos by digging down to expose the rhizome system (1-2 feet below ground) and cutting it off from the parent clump. The culm itself may be cut back to 2 feet in length. Offsets obtained in this manner are probably best taken in early April, shortly before the new culms grow. It is important not to damage the underground bud when exposing the rhizome. These offsets can then be planted out in cultivated ground and will develop quicker than plants raised from seed.

UTILIZATION OF BAMBOO

As has already been stated above, a full crop of bamboo generally consists of 4,000 to 7,000 culms per acre. They yield when cut about 40 tons of air-dry bamboos per acre.

The length of usable culm is about 25-30 feet (down to 1 inch diameter). A freshly cut bamboo weighs 35 to 50 lb. It will dry out in three months to 25-35 lb.

Bamboos under two years old are young 50 ft. culms which have not got the strength and rigidity of mature culms, and they should not be cut for poles. They can easily be recognized by their rich green colour and smooth downy stems (*see Life of a Bamboo Culm*).

When bamboos are cut for use as round poles it is best to saw off the ends, making the saw-cut through one of the nodes, the solid thickened joints that occur at intervals of 1½-2 feet all the way up the stem. This makes the ends stronger and not so liable to shatter, as they are apt to do if the cut is made through the hollow portion or internode of the stem.

As cut bamboos dry out they are much liable to damage by a small powder-post beetle (*Dinoderus minutus* and others) which bores into the wood of the bamboo. Apart from reducing the strength of the bamboo, this damage is a nuisance; for instance, when it occurs in bamboo roofing poles a shower of fine powdered frass continually falls from the roof.

PRESERVATIVE TREATMENT OF BAMBOOS

It is possible by a simple preservative treatment to render bamboos proof against damage by borer beetles. This is by standing the freshly cut bamboos *with all their leaves on* for twenty-four hours with their butt ends in a water solution of chemical preservative. It has been found that the bamboos will suck up the preservative solution to a height of 15-20 feet, the absorption being 1-2 pints per bamboo. For this treatment to be effective the bamboos must be standing in the solution within half-an-hour after cutting (the sooner the better) and a fresh cut one foot from the end must be made immediately before the butt is plunged into the solution: the surface of the cut must be clean and not choked with earth or dust, as will happen if it is allowed to touch the ground after the final cut is made.

Tests carried out recently by the Senior Entomologist at the Scott Agricultural Laboratories, Nairobi, on bamboos treated by the Forest Department have indicated that a 2½ per cent solution of "Wolman Salts" (1 lb. of salts to every four gallons of water) is effective in preventing attack by borer beetles. Treatment with a 2½ per cent solution of borax gave only slight protection against borers. Further tests made on bamboos treated with a 4 per cent solution of borax were, however, successful in keeping out the borers.

CONCLUSION

In conclusion it may be said that although this article gives a summary of what has been learnt by observation of alpine bamboo over the past decade, it is certain that there is still much to be learnt from further study of this fascinating and useful plant. It is likely that our present knowledge will need revision in the light of future study and experience.

SECOND SUPPLEMENT TO THE REVISED LIST OF PLANT DISEASES IN TANGANYIKA TERRITORY

By **G. B. Wallace, B.Sc. (Agric.), Ph.D. (Edin.), and M. M. Wallace, B.Sc. (Hons.), M.Sc. (Lond.), Department of Agriculture, Tanganyika Territory**

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The following list supplements those given in this Journal in Vol. II, pages 305 to 310 (1939) and Vol. X, pages 47 to 49 (1944). Diseases are listed under the host plants, and of these the common name is given where possible. A few non-parasitic diseases have been included. These lists thus enumerate all the parasitic diseases, recorded up to the end of March, 1947, on plants which can be considered economic in this Territory. The lists will be combined at a later date.

Acknowledgment is made to the Director and staff of the Imperial Mycological Institute, Kew, and to Mr. C. G. Hansford, late of Uganda, for the identification of certain fungi. Dr. D. C. Bain of Louisiana State University kindly confirmed the identity of the Gloeocercospora on Pennisetum, and identified the Ramulispora on Sorghum. Dr. V. A. Wager of Durban named the Pythium on vegetable marrow.

Albizzia gummifera, C. A. Smith

Armillaria root rot, *A. mellea* (Vahl ex Fr.) Quél.

Apple (*Pyrus malus* Linn.)

Armillaria root rot, *A. mellea* (Vahl ex Fr.) Quél.

Bitter rot, *Glomerella cingulata* (Stonem.) Spauld and Schrenk., conidia

Root disease, *Ustulina zonata* (Lév.) Sacc.

Asclepias curassavica Linn.

Mildew, *Leveillula taurica* (Lév.) Arn.

Atropa belladonna Linn.

Leaf spot, *Cercospora* sp.

Wilt, a Pythiaceous fungus

Bambarra groundnut (*Voandzeia subterranea* Thou.)

Leaf spot, *Cercospora canescens* Ell. and Mart., type

Barberton Daisy (*Gerbera jamesonii* Hook.)

Leaf spot, *Cercospora* sp.

Leaf spot, *Septoria gerberae* Syd.

Sclerotium disease, *S. rolfsii* Sacc.

Barley (*Hordeum vulgare* Linn.)

Leaf blotch, *Rhynchosporium secalis* (Oudem.) J. J. Davis

Leaf spot, *Helminthosporium sativum* P. K. and B.

Yellow rust, *Puccinia glumarum* (Schm.) Erikss. and Henn.

Beans

Bonavist bean (*Dolichos lablab* Linn.)

Damping off, *Corticium solani* (Prill. and Delacr.) Bourd. and Galz.

French bean (*Phaseolus vulgaris* Linn.)

Leaf spot *Cercospora stuhlmanni* P. Henn., recorded by Hennings in 1902

"Sun scorch", possibly a deficiency disease

Lima bean (*Phaseolus lunatus* Linn.)

Bacterial spot on leaves

Mildew, *Leveillula taurica* (Lév.) Arn.

On pods, *Epicoccum purpurascens* Ehrenb., probably saprophytic

Pod spot, *Colletotrichum truncatum* (Schw.) Andrus and Moore

Pod spot, *Macrophomina phaseoli* (Maubl.) Ashby

"Rust", *Synchytrium dolichi* (Cke.) Gaüm.

Stem spot, *Cercospora canescens* Ell. and Mart.

Stem spot, *Phomopsis phaseoli* (Desm.) Grove

Soy bean (*Glycine max* (Linn.) Merr.)

Bacterial leaf spot

Leaf spot, *Ascochyta phaseolorum* Sacc.

Leaf spot, *Cercospora* sp.

Root disease, *Macrophomina phaseoli* (Maubl.) Ashby

Borage (*Borago officinalis* Linn.)

Sclerotinia disease, *S. sclerotiorum* (Lib.) de Bary

Bullock's heart (*Annona reticulata* Linn.)

Anthracnose of fruit, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk., on Helopeltis scabs

Bulrush millet (*Pennisetum typhoides* Stapf and Hubbard)
  Zonate leaf spot, *Gloeocercospora sorghi* Bain and Edgerton

Carambola (*Averrhoa carambola* Linn.)
  Leaf spot, *Cercospora averrhoae* Petch

Carnation (*Dianthus caryophyllus* Linn.)
  On stems, *Colletotrichum capsici* (Syd.) Butler and Bisby group
  On stems, *Macrophomina phaseoli* (Maubl.) Ashby

Cassava (*Manihot utilissima* Pohl)
  Eutypella sp. on roots

Cassia laevigata Willd.
  Leaf spot, *Cercospora cassiae* P. Henn.
  Pink disease, *Corticium salmonicolor* Berk. and Br.
  Root disease, *Macrophomina phaseoli* (Maubl.) Ashby

Cauliflower (*Brassica oleracea* var. *botrytis* Linn.)
  Brown rot, *Alternaria brassicae* (Berk.) Sacc.
  Dark leaf spot, *Alternaria oleracea* Milbr.

Centaurea sp.
  Leaf spot, *Cercospora bidentis* Tharp.

Citrus
  Grapefruit (*Citrus paradisi* Macf.)
    Anthracnose of fruit, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk., conidia
    Green mould, *Penicillium digitatum* Sacc.
    Leaf chlorosis, zinc deficiency
  Lemon (*Citrus limonia* Osbeck)
    Green mould, *Penicillium digitatum* Sacc.
    Scab, *Elsinoë fawcetti* Bitanc. and Jenkins, in conidial stage *Sporotrichum citri* (Butler) Doidge and Butler

Clarkia elegans Douglas
  Mildew, *Leveillula taurica* (Lév.) Arn.

Coffea arabica Linn.
  Various physiological diseases:—
    Leaf spots resulting from toxic action of *Grevillea robusta* flowers and Sesbania flowers
    Collar rot, associated with presence of leaf mould
    Scorch, associated with overbearing
    Yellowing and leaf fall, copper deficiency
    Die back, associated with exposure

Coffea excelsa A. Chev.
  Brown blight, *Colletotrichum coffeanum* Noack
  Rust, *Hemileia vastatrix* Berk. and Br.

Coffea liberica Bull ex Hiern
  Rust, *Hemileia vastatrix* Berk. and Br.

Coffea robusta Lind.
  Brown blight, *Colletotrichum coffeanum* Noack
  Rust, *Hemileia vastatrix* Berk. and Br.

Cotton (*Gossypium hirsutum* Linn.)
  Ascochyta blight, *A. gossypii* Syd.
  Damping off, *Corticium solani* (Prill. and Delacr.) Bourd and Galz.
  Leaf spot, *Alternaria macrospora* Zimmerm.

Cowpea (*Vigna unguiculata* (Linn.) Walp.)
  Rust, *Uromyces appendiculatus* (Pers.) Link

Crucifer
  White blister, *Cystopus candidus* (Pers. ex Chev.) Lév.

Cucumber (*Cucumis sativus* Linn.)
  Seedling disease and fruit rot, *Mycosphaerella citrullina* (C. O. Smith) Grossenb.

Egg plant (*Solanum melongena* Linn.)
  Anthracnose of fruit, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk., conidia
  Fruit rot, *Phytophthora melongenae* K. Sawada
  Leaf spot, *Cladosporium herbarum* Link ex Fr.
  Leaf spot, *Alternaria* sp., of "solani" group

Eschscholtzia sp.
  Mildew, *Leveillula taurica* (Lév.) Arn.

Eucalyptus sp.
  Leaf spot, *Sphaerella molleriana* Thüm.

Ginger (*Zingiber officinalis* Rosc.)
  Anthracnose of leaves, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk., conidia

Grape vine (*Vitis vinifera* Linn.)
  Leaf spot, *Cercospora viticola* (Ces.) Sacc.

Grasses
- Napier fodder (*Pennisetum purpureum* Schum.)
  - Zonate leaf spot, *Gloeocercospora sorghi* Bain and Edgerton

Panicum Hanningtonii Stapf
- Ergot, *Claviceps* sp., *Sphacelia* stage, with *Cerebella* sp. secondary

Pennisetum sp. (indig.)
- Downy mildew, *Sclerospora graminicola* (Sacc.) Schroet.

Groundnut (*Arachis hypogaea* Linn.)
- Collar rot, *Sclerotium rolfsii* Sacc.
- Leaf spot, *Cercospora arachidicola* Hori

Leek (*Allium porrum* Linn.)
- Mildew, *Leveillula taurica* (Lév.) Arn.
- Purple blotch, *Alternaria porri* (Ell.) Neergaard

Lettuce (*Lactuca sativa* Linn.)
- Heart rot, physiological
- Leaf spot, *Cercospora longissima* Trav.
- Leaf spot, *Septoria lactucae* Pass., (on var. "Celtuce")
- Sclerotina rot, *S. sclerotiorum* (Lib.) de Bary

Lucerne (*Medicago sativa* Linn.)
- Leaf spot, *Pseudoplea trifolii* (Rostr.) Petrak
- Stem spot, *Colletotrichum capsici* (Syd.) Butler and Bisby group
- Root rot, *Sclerotium rolfsii* Sacc.

Lupin (*Lupinus* sp.)
- Root rot, *Sclerotium rolfsii* Sacc.

Maize (*Zea mays* Linn.)
- Stripe, virus disease

Mango (*Mangifera indica* Linn.)
- Leaf spot, *Cercospora mangiferae* Koord.

Marigold (*Calendula officinalis* Linn.)
- Leaf spot, *Cercospora ?calendulae* Sacc.

Millet, finger (*Eleusine coracana* Gaertn.)
- Leaf spot, *Cercospora fusimaculans* Atk.
- Leaf spot, *Helminthosporium ?nodulosum* B and C.
- Leaf spot, *Phyllachora eleusines* Speg.

Nicotiana sp., garden variety
- Mildew, *Leveillula taurica* (Lév.) Arn.

Oak (*Quercus* sp.)
- Mildew, *Oidium quercinum* Thüm.

Oats (*Avena sativa* Linn.)
- Crown rust, *Puccinia coronata* Corda
- Leaf spot, *Helminthosporium avenae* Eidam

Olive (*Olea europea* Linn.)
- Leaf spot, *?Coniothyrium oleae* Polac.

Onion (*Allium cepa* Linn.)
- Downy mildew, *Peronospora destructor* (Berk.) Casp., (followed by *Stemphylium botryosum* Wallr.)

Orchids
- Bacterial rot

Papaw (*Carica papaya* Linn.)
- Armillaria root rot, *A. mellea* (Vahl ex Fr.) Quél.
- Black spot of fruit, *Ascochyta caricae* Pat.
- Fruit rot, *Colletotrichum capsici* (Syd.) Butler and Bisby group
- Fruit rot, *Phytophthora parasitica* Dast.
- Root rot, *Botryodiplodia theobromae* Pat.
- Root rot, *Pythium aphanidermatum* (Eds.) Fitz.
- Stem rot, *Macrophomina phaseoli* (Maubl.) Ashby, sclerotia

Passion fruit (*Passiflora ligularis* Juss.)
- Anthracnose of fruit, *Glomerella cingulata* (Stonem.) Spauld and Schrenk., conidia

Pea, field (*Pisum sativum* Linn.)
- Mosaic, virus disease

Pear (*Pyrus communis* Linn.)
- Bitter rot of fruit, *Glomerella cingulata* (Stonem.) Spauld. and Schrenk., conidia

Phlox drummondii Hook.
- Leaf spot, *Septoria* sp.
- Mildew, *Leveillula taurica* (Lév.) Arn.

Poinsettia (*Euphorbia pulcherrima* Willd.)
- Rust, *Melampsora* sp., uredospores only

Poppy, Shirley (*Papaver rhoeas* Linn.)
- Bacterial disease, unidentified

Potato (*Solanum tuberosum* Linn.)
- Brown rot, *Xanthomonas solanacearum* (E. F. Sm.) Dowson
- Leaf roll, virus
- Mosaic, virus
- Stem rot, *Macrophomina phaseoli* (Maubl.) Ashby, sclerotia

Pumpkin (*Cucurbita pepo* Linn.)
- Leaf spot, *Phyllosticta orbicularis* Ellis and Everh.

Pyrethrum (*Chrysanthemum coccineum* Willd.)
- Sclerotinia rot, *S. sclerotiorum* (Lib.) de Bary

Rhubarb (*Rheum rhaponticum* Linn.)
- Leaf spot, *Phyllosticta* sp.
- Petiole spot, *Colletotrichum capsici* (Syd.) Butler and Bisby group

Rubber, Ceara (*Manihot glaziovii* Muell.-Arg.)
- Leaf spot, *Cercospora henningsii* Allesch.

Rubber, Para (*Hevea brasiliensis* Muell.-Arg.)
- Mildew, *Oidium heveae* Steinmann

Rye (*Secale cereale* Linn.)
- Stem rust, *Puccinia graminis* Pers. f. *secalis*
- Yellow rust, *Puccinia glumarum* (Schm.) Erikss.

Sorghum (*Sorghum vulgare* Pers.)
- Leaf spot, *Cercospora* sp., (not *C. sorghi*)
- Leaf spot, *Colletotrichum graminicola* (Ces.) G. W. Wils.
- Leaf spot, *Helminthosporium turcicum* Pass.
- Sooty stripe, *Ramulispora sorghi* (Ellis and Everh.) Olive and Lefebvre (Syn.: *Titaeospora andropogonis* Tai, and *Ramulispora andropogonis* Miura)

Sowthistle (*Sonchus oleraceus* Linn.)
- Downy mildew, *Bremia lactucae* Regel

Spinach, New Zealand (*Tetragonia expansa* Murr.)
- Leaf spot, *Alternaria* sp.
- Leaf spot, *Cercospora* sp.
- Stem spot, *Colletotrichum capsici* (Syd.) Butler and Bisby group

Strawberry (*Fragaria vesca* Linn.)
- Grey mould, *Botrytis cinerea* Fr.

Sugar cane (*Saccharum officinarum* Linn.)
- Agaul mosaic, virus
- On stalks and sheaths, *Melanconium sacchari* Mass.
- Red rot, *Colletotrichum falcatum* Went.

Sunn hemp (*Crotalaria juncea* Linn.)
- Leaf spot, *Cercospora demetrioniana* Wint.

Sweet potato (*Ipomoea batatis* (Linn.) Lam.)
- Leaf spot, *Cercospora ipomoeae* Wint.
- Stem disease, *Plenodomus destruens* Harter
- Stem and root rot, *Macrophomina phaseoli* (Maubl.) Ashby
- Virus disease

Tea (*Camellia sinensis* (Linn.) Kunze)
- Leaf spot, *Mycosphaerella* sp.
- Leaf spot, *Pestalotia theae* Sawada
- Leaf spot resulting from toxic action of *Tephrosia vogelii* flowers
- Root disease, *Botryodiplodia theobromae* Pat.
- Seedling disease, *Macrophomina phaseoli* (Maubl.) Ashby

Tobacco (*Nicotiana tabacum* Linn.)
- Red rust (physiological)

Tomato (*Lycopersicum esculentum* Mill.)
- Brown rot, *Xanthomonas solanacearum* (E. F. Sm.) Dowson
- Irish blight, *Phytophthora infestans* (Mont.) de Bary

Vegetable marrow (*Cucurbita pepo* Linn.)
- Fruit rot, *Pythium acanthicum* Drechsler
- Fruit rot and seedling disease *Mycosphaerella citrullina* (C. O. Smith) Grossenb.
- Powdery mildew, *Erysiphe cichoracearum* DC.

Violet (*Viola odorata* Linn.)
- Corticium disease, *Corticium solani* (Prill. and Delacr.) Bourd. and Galz.

Yam (*Dioscorea* sp.)
- Rust, uredospores only

Zinnia elegans Jacq.
- Leaf spot, *Cercospora zinneae*

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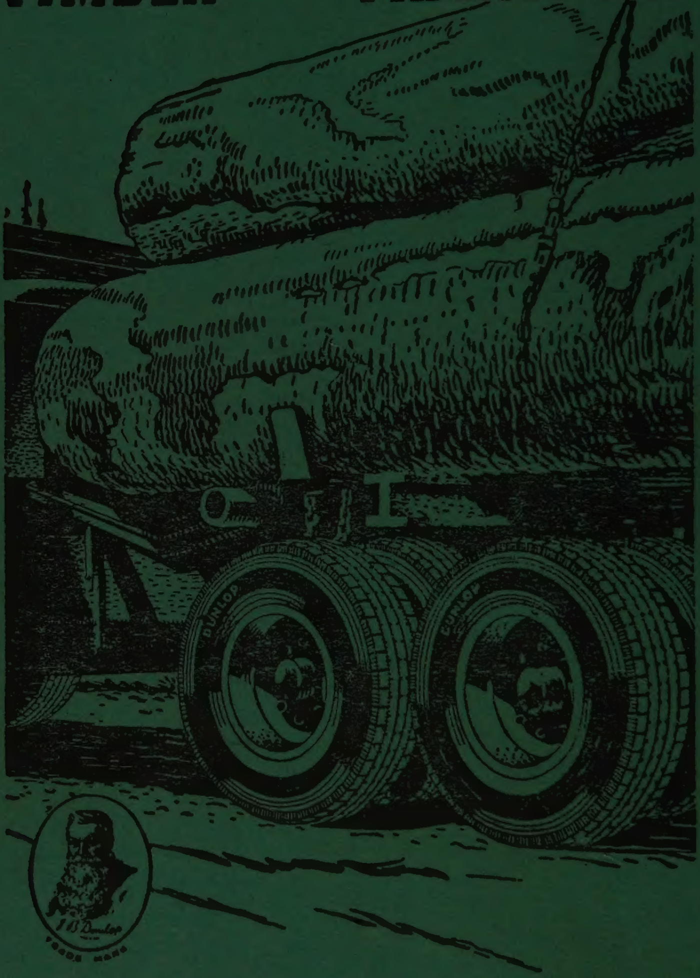

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